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ABSTRACT

This report, submitted to the Congress by President Ford in accordance with the National Aeronautics and Space Act of 1958, summarizes the United States' space and aeronautics activities for the year 1975. Detailed summaries of the activities of the following governmental departments or agencies are provided: National Aeronautics and Space Administration; Departments of Defense, Commerce, Interior, Agriculture, State, and Transportation; Energy Research and Development Administration; National Science Foundation; Environmental Protection Agency; National Academy of Sciences; Federal Communications Commission; the Smithsonian Institution; and the United States Information Agency. Scientific investigations concerning the universe, solar system, and the Earth's space environment, atmosphere, and surface features are detailed. The appendices contain information relating to the United States Spacecraft record (1957-1975), the World Record, the history of the United States and Soviet manned space flights, space launch vehicles, the space budget, launched scientific payloads (1971-1975) and launched space probes (1971-1975). (BT)

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Aeronautics and Space Report of the President

1975 Activities

SE 021 306

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Aeronautics and Space Report of the President

1975 Activities

National Aeronautics and Space Administration
Washington, D.C. 20546

President's Message of Transmittal

To the Congress of the United States:

I am pleased to transmit this report on the Nation's progress in space and aeronautics during 1975. This report is provided in accordance with Section 206 of the National Aeronautics and Space Act of 1958 as amended (42 U.S.C. 2476).

1975 was another year of continued progress in the Nation's space and aeronautics activities. It marked significant accomplishments in many areas.

Earth-orbiting satellites continued to bring new and increased benefits in a variety of applications. Two additional international communications satellites were launched, expanding the already impressive international satellite communications capability. A second domestic commercial communications satellite was put into operation. Military satellite communications were enhanced. In addition, a new system of satellites for global weather reporting was initiated, providing reports every thirty minutes on weather across half the globe.

Landsat 2 was orbited to join Landsat 1 to provide additional Earth sensing data to explore potential uses in a wide range of activities, including crop forecasting, pollution monitoring, forestry and land use studies, and in mineral exploration.

I had the pleasure and thrill of talking to our astronauts and the Soviet cosmonauts when they linked up in space at the culmination of the historic U.S.-U.S.S.R. Apollo Soyuz Test Project.

Major milestones were met in the development of the Space Shuttle, the Nation's current major space project. Canada agreed to develop the remote manipulator system for the Shuttle, a major and welcome contribution.

Development of Spacelab, a key system to take advantage of the capability of the Space Shuttle and being built and funded by the European Space Agency, continued on schedule.

We continued to probe the unknown in space. Pioneer 10 will be the first man-made object to venture beyond our solar system. Pioneer 11 will make the first flyby of Saturn in 1979. In passing Jupiter these vehicles sent back pictures that added greatly to our knowledge of the largest planet. Last August and September we launched two Viking spacecraft toward Mars. They will arrive at the height of our Bicentennial celebration and may provide information on the existence of life in some form on our neighboring planet.

In aeronautics, research focused on the technologies needed to reduce fuel requirements, noise, and pollution. Also emphasized was improved reliability, performance, and safety. Military aircraft development featured the first supersonic flight of the B-1, the operational deployment of the F-14 and F-15, and the selection of the F-16 and F-18 as future fighter aircraft.

The fruits of our research continued to be enjoyed by the transfer of space and aeronautics technology to many beneficial uses in our society, including energy research, medical care, transportation, and new techniques and materials for manufacturing.

Our Nation's activities in aeronautics and space continue to be a major contribution to our quality of life and economic growth.

We can all take pride in our commitment to advancement in space and aeronautics as reflected in the accomplishments described in this report.

THE WHITE HOUSE,
June 1976

GERALD R. FORD

Table of Contents

Page
- I. Summary of U.S. Aeronautics and Space Activities in 1975 1
  - Introduction 1
  - Space 1
  - Aeronautics 5
- II. National Aeronautics and Space Administration 7
  - Introduction 7
  - Study of the Universe and the Sun-Earth Relationship 7
  - Exploration of the Planets and the Moon 10
  - Life Sciences 11
  - Study of the Earth's Atmosphere 12
  - Applications to Earth 12
  - NASA Energy Program 16
  - Space Flight 17
  - Space Flight Transportation 17
  - Tracking and Data Acquisition 19
  - International Affairs 21
  - University Affairs 23
  - Space and Nuclear Research and Technology 23
  - Aeronautics Research and Technology 24
  - Disseminating Technology and Benefits 26
- III. Department of Defense 27
  - Introduction 27
  - Space Activities 28
  - Space Ground Support 30
  - Space Research and Technology 31
  - Aeronautical Activities 32
  - Relationship with NASA 36
- IV. Department of Commerce 38
  - Introduction 38
  - Satellites in Environmental Monitoring and Prediction 38
  - Other Satellite and Space Applications 41
  - Space Support Activities 43
  - Space and Atmospheric Physics Research 44
  - Data Programs 45
  - Aeronautical Programs 46
- V. Energy Research and Development Administration 47
  - Introduction 47
  - Viking Mars Lander 47
  - Lincoln Experimental Satellite (LES) 47
  - Mariner Jupiter/Saturn 48
  - Generator Technology 48
- VI. Department of the Interior 49
  - Introduction 49
  - Space 49
  - Aeronautics 53
  - International Activities 55
- VII. Department of Agriculture 56
  - Introduction 56
  - Remote Sensing Activity 56
- VIII. National Science Foundation 58
  - Introduction 58
  - Astronomy 58
  - Atmospheric Sciences 59
  - Polar Research Programs 59
  - Engineering 60
  - Materials Research 60
  - Education Activities 60
- IX. Environmental Protection Agency 61
  - Introduction 61
  - Energy-Related Environmental Research and Development 61
  - Advanced Monitoring Programs 63

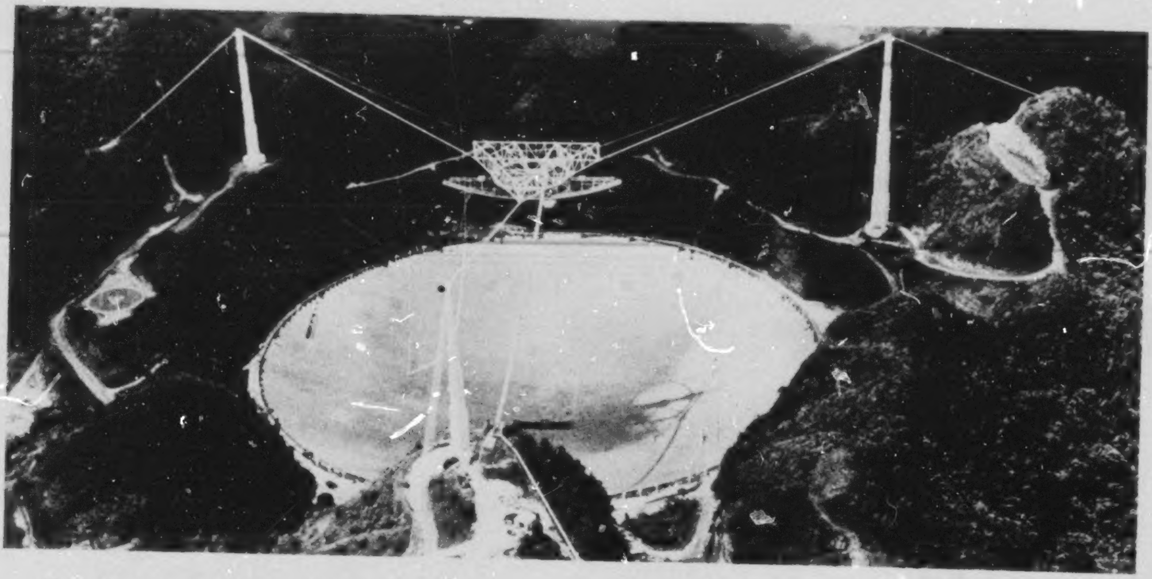
Page
- X. National Academy of Sciences, National Academy of Engineering, National Research Council 65
  - Introduction 65
  - Aerospace Science 65
  - Space Applications 67
  - Aerospace Engineering 68
  - Education 69
- XI. Office of Telecommunications Policy 70
  - Introduction 70
  - AEROSAT 71
  - INMARSAT 71
  - Proposed Amendments to the Communications Satellite Act of 1962 71
  - Direct Broadcast Satellites 72
  - Frequency Management 72
  - High Power Satellites 73
- XII. Federal Communications Commission 75
  - Introduction 75
  - Communications Satellites 75
  - Specialized Satellite Services 76
  - International Telecommunications Union (ITU) 77
  - Frequency Allocation and Coordination 77
- XIII. Department of State 78
  - Introduction 78
  - Activities within the United Nations 78
  - International Cooperation 79
  - Satellite Services 80
  - Support of Federal Agencies 81
- XIV. Arms Control and Disarmament Agency 82
  - Introduction 82
  - Demilitarization 82
  - Crisis Management and Verification 82
  - Space Technology 82
- XV. Department of Transportation 83
  - Introduction 83
  - Office of the Secretary (OST) Programs 83
  - FAA Research and Development: Aviation Safety 84
  - Air Traffic Control and Navigation 85
- XVI. The Smithsonian Institution 88
  - Introduction 88
  - Smithsonian Astrophysical Observatory 88
  - National Air and Space Museum 89
- XVII. United States Information Agency 91
  - Introduction 91
  - Radio 91
  - Press and Publications 91
  - Films and Television 92
  - Information Centers and Exhibits 93

Appendixes

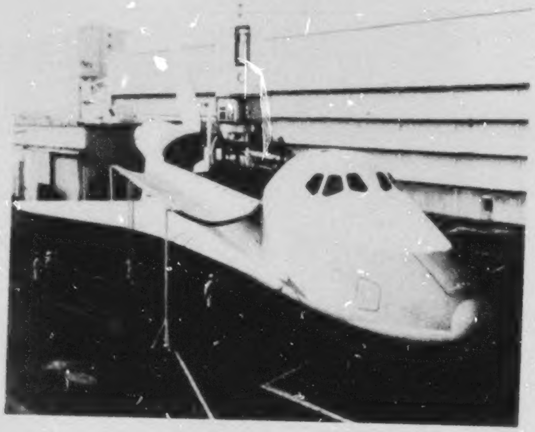
- A-1 U.S. Spacecraft Record 94
- A-2 World Record of Space Launchings Successful in Attaining Earth Orbit or Beyond 94
- A-3 Successful U.S. Launchings—1975 95
- B-1 U.S. Applications Satellites, 1971-1975 104
- B-2 U.S.-Launched Scientific Payloads, 1971-1975 106
- B-3 U.S.-Launched Space Probes, 1971-1975 107
- C History of United States and Soviet Manned Space Flights 108
- D U.S. Space Launch Vehicles 110
- E-1 Space Activities of the U.S. Government 111
  - U.S. Space Budget Budget Authority 111
- E-2 Space Activities Budget 112
  - Aeronautics Budget 112

New Tools for Space Research

An increasing array of Earth-based and spacecraft-borne instruments and sensors is joining together to study the planets of our solar system, the Sun, our galaxy, and the far reaches of the universe.



Nestled in a natural bowl near Arecibo, Puerto Rico, is the big radio/radar telescope of the National Science Foundation. The 300-meter-diameter dish was resurfaced with aluminum panels to a spherical precision within 3.2 millimeters, an improvement that broadened the frequency range for scientific observations by a factor of 12. A new 450-kilowatt S-band planetary radar transmitter was sponsored by the National Aeronautics and Space Administration. It raised the facility's capability for radar ranging and surface mapping of the planets by a factor of 1000. The new equipment began operation in 1975, mapping the surface of cloud-shrouded Venus to include terrain details as small as two kilometers. It also surveyed the sites on Mars where the Viking landers will set down in 1976.



This mockup of the Space Shuttle orbiter was used to make detailed studies of a full-scale model of the Low Cost Modular Spacecraft. This spacecraft was one of several modular configurations being studied by NASA's Goddard Space Flight Center as economical means to place spacecraft into orbit from the orbiter and later to resupply or retrieve them. The first prototype orbiter is scheduled for rollout in September 1976.

I

Summary of United States Aeronautics and Space Activities in 1975

Introduction

The past year has been one of significant achievements in space and aeronautics. Scientific investigations advanced our understanding of the universe, the solar system, and the Earth's space environment, atmosphere, and surface features. At the same time, operational satellite systems for weather data and communications were functioning with increased reliability and diversity. A manned Apollo spacecraft joined a Soviet spacecraft in orbit for an international experiment and progress on the Space Shuttle continued with the fabrication and construction of the two prototypes. Aeronautical research made advances toward quieter, more economical, and safer aircraft.

Space

The United States had 34 launches into space in 1975. We orbited 30 spacecraft, while 4 failed to achieve the desired orbit. The Department of Defense had 11 successful launches, NASA 19. Of NASA's total, 3 were commercial communications satellites, 2 launched for INTELSAT and 1 for RCA; one was for the U.S. Navy; 2 were for the National Oceanic and Atmospheric Administration (NOAA); and 3 were international satellites launched for Canada, the European Space Agency, and Germany and France. Of spacecraft launched for NASA's own program, 4 were scientific satellites, 3 were applications satellites, 1 was a manned flight, and 2 were planetary probes.

The Universe

Exploration of the universe seeks to answer fundamental questions: How big is the universe? When did it begin? What are the dynamics of the birth, life, and death of stars? What are the processes of creation, sustenance, and deterioration of enormous sources of energy? Are there other solar systems in the universe similar to ours? If there are, is there life on those planets? NASA's space science program, which focuses on these questions, continued to make significant gains during 1975.

The last of the Small Astronomy Satellites, SAS-C (Explorer 53), was orbited in 1975 to pursue the study of galactic and extra-galactic sources of radiation. It joined a small fleet of other satellites making similar measurements. Among them was OAO-3 (Copernicus), launched in 1972, which this year identified a star other than our own Sun that had a corona (halo of high-temperature gas), but with temperatures in the gas much below predicted levels. This suggests that comparison of a number of stars and their coronal variations could tell us much about the different kinds of stars. Meanwhile, work continued on design and fabrication of the first High Energy Astronomy Observatory (HEAO-A), which will be instrumented to study recently discovered phenomena such as pulsars, quasars, and black holes. Ground-based radio telescopes of the National Science Foundation and sounding rocket and balloon X-ray experiments by the Smithsonian Institution conducted complementary studies of these and other phenomena in 1975.

The Solar System

Using both ground-based observatories and spacecraft, the pursuit of knowledge about our solar system continued with studies of the planets, the Sun, the Moon, and the interplanetary medium.

Planetary Exploration. In the past year, three planetary spacecraft successfully continued their missions, two were launched, and four continued into development. Mariner 10, which flew by Venus in 1974, was the first spacecraft to use the gravitational force of one planet to accelerate toward another planet. Mariner 10 made three close passes of the planet Mercury and took close-up photographs; and discovered the presence of a weak magnetic field around the planet.

The Pioneer 10 and 11 spacecraft which were launched in 1972 and 1973 and sent back photographs of Jupiter in 1974, continued their exploration of the outer regions of the solar system. During 1975 Pioneer 10 headed on a course that would take it out of the solar system by about 1987, the first man-made object to venture into interstellar space. Pioneer 11 travelled across the solar system toward a

1979 flyby of Saturn, for a first look at that planet and its unique rings. Also the most ambitious planetary exploration to date—the Viking Mars orbiter/lander mission—was launched in the summer of 1975. When it arrives at Mars in the summer of 1976, the first Viking spacecraft is to orbit the planet for several weeks, confirm a landing site, and the lander spacecraft is to descend to the surface of Mars to softland and spend 60 days taking photographs, sampling the atmosphere, and testing the Martian soil for evidence of extraterrestrial life. The same pattern will be repeated later in the year by the second Viking lander.

Looking ahead, NASA is preparing two future planetary missions involving two spacecraft each. The Mariner Jupiter/Saturn mission, to be launched in 1977, will swing past Jupiter in 1979, then move on to pass Saturn in 1981. The Pioneer Venus mission will consist of two spacecraft to be launched to Venus in 1978, one to orbit the planet, the other to drop probes to the Venusian surface.

Study of the Sun. Study of the energy source of of the solar system, the Sun, continued in 1975 with the launch of the last and largest of the observatory-class solar satellites, the Orbiting Solar Observatory (OSO-I). It will measure a number of solar phenomena during the low point (or quiet phase) of the 11-year solar activity cycle. Helios-A, the U.S.-German cooperative satellite launched in 1974, flew nearer the Sun than any previous satellite, and collected data on solar radiation. Work continued on the second satellite, Helios-B, scheduled to be launched in early 1976. Data analysis of observations from the Apollo Telescope Mount carried on the Skylab flights, between May 1973 and February 1974, continued in 1975. Among other findings was evidence that the cool spots on the solar surface reached to deeper levels in the Sun than previously known. In addition, design and advanced technology development continued on the Solar Maximum Mission, which is designed to study the Sun during the next period of solar flare activity (1979-1980).

Studies of the Moon. Analysis and laboratory research progressed on lunar soil samples and other lunar data. Studies of the lunar soil samples from the Apollo program identified lunar mare basalt as having been laid down as lava flows 3.1 to 3.8 billion years ago. These samples came from a region that had been chemically isolated 4.4 billion years ago, very close to the probable 4.6-billion-year age of the Moon and the Earth. In addition, instruments left on the lunar surface continued to send back important data on lunar events.

Earth's Environment

Understanding the Upper Atmosphere. In the past the majority of NASA's scientific satellites have studied the complex interactions of incoming radiation between the Earth's magnetic field and the various layers of the upper atmosphere. Emphasis on investigations of the upper atmosphere was continued in 1975 with the launch of two scientific satellites with diverse missions but with one new technological advantage—an upgraded onboard propulsion system that makes it possible to repeatedly dip in and out of the lower reaches of the upper atmosphere to catch samples of particles without being pulled into the lower atmosphere and burning up. Atmosphere Explorer D (AE-D) (Explorer 54) was launched into polar orbit in October. AE-E (Explorer 55) was launched into low-inclination orbit in November. Together they are designed to provide global studies of effects of solar ultraviolet radiation on the makeup of the lower thermosphere and down into lower levels where most of the radiation is absorbed. Data from these satellites are now being received. As they are interpreted and pieced together over the next several years, they should greatly improve our understanding of the detailed structure and processes in those layers of the atmosphere that protect the Earth's surface from the Sun's ultraviolet radiation. Complementary studies will be carried out by the National Science Foundation in conjunction with the International Magnetospheric Study of the near-Earth environment and ways in which it is influenced by the Sun. The Department of Transportation, NOAA, the National Academy of Sciences, and NASA have been gathering data on the possible threat to the ozone layer that is posed by the loss of ozone to halogens released from Earth as fluorine and chlorines.

In 1975 Congress assigned to NASA the responsibility for continuing study of the upper atmosphere and coordination of research results with other agencies. The long-term effort will seek to develop instrumentation to monitor conditions in the upper atmosphere so as to better understand the physical and chemical processes in this region. The immediate effort focuses on the problems of the ozone layer and halogens. During 1975, several constituents thought dangerous to ozone were measured by a NASA research balloon and a U-2 aircraft.

Predicting the Weather. In the last decade environmental satellites have significantly improved mid-range and longer-range forecasting by the global scale of their observations and the cumulative real-time data they have produced. Advances in short-range forecasting have been less pronounced, partly because general weather patterns are modified by local conditions and partly because local changes are too rapid and too detailed for global-coverage satellites to discern. Accurate short-range forecasts are particularly important in the identification and tracking of severe storms, such as tornadoes. To improve such forecasts, the National Oceanic and Atmospheric Administration (NOAA) of the Department of Commerce sponsored the development of a new kind of environmental satellite, the Synchronous Meteorological Satellite (SMS). One SMS in synchronous orbit over each coast of the North American continent would observe the detailed weather conditions over the continent and its approaches every 30 minutes. The first of these prototypes was placed in orbit over the east coast for NOAA by NASA in 1974. In February 1975 SMS-2 was launched into orbit over the west coast, and in October an operational system was inaugurated with the launch of GOES-1 (Geostationary Operational Environmental Satellite). NOAA-4, backed up by NOAA-3, continued to provide the operational global weather data from polar orbit.

Nimbus 6, most recent in the series of NASA experimental weather satellites, was launched in June to test advanced sensors as well as to supply supplemental weather data to NOAA and serve as a data-collection and relay satellite for sensors on remote platforms. Development continued on Tiros-N, NASA prototype of the third-generation operational weather satellite. Tiros-N will be launched into orbit in 1978.

On the ground the network of stations for use and dissemination of GOES data was completed during 1975. Now 50 weather stations have equipment for receiving the satellite data and transmitting local short-term forecasts and advisories. With this capability came the improved GOES-TAP system, which disseminates satellite weather photographs to television stations, local governments, universities, and Federal agencies. In August the GOES Data Collection System became operational, enabling users to collect environmental data from a variety of remote sensor platforms.

Satellites as Communicators. The earliest commercial application of space technology was the use of satellites in orbit above the Earth as a means of efficient relay of long-distance communications. In 1975 communications satellite systems further augmented their capacity and networks, continuing their rapid expansion as a major factor in global long-distance and middle-distance communications. Further advances in satellite communications technology were sought through investigations conducted with NASA's Advanced Technology Satellite (ATS-6), development of Canada's Communications Technology Satellite, and both technological and organizational work on expanding the number of usable channels in the frequency spectrum.

INTELSAT, the international communications-satellite consortium, added another Intelsat IV satellite in May to maintain the capability of its worldwide communications network. In September the first of a new series of upgraded spacecraft, Intelsat IVA, was launched by NASA for INTELSAT. Expansion of the more recently established field of domestic communications satellites continued with the NASA launch of Canada's Anik 3 in May and of RCA-1 in December. Final preparations were being made for the launch of Canada's Communications Technology Satellite in 1976, which will experiment with communications for education, health, social service, and information exchange using low-cost ground receiving stations.

The versatile ATS-6 satellite spent the early part of 1975 conducting experiments in delivery of health, educational, medical-diagnosis, and social-service information to small, inexpensive antennas in remote areas of Alaska, Appalachia, and the Rocky Mountains. After serving as a communications link in support of the U.S.-U.S.S.R. Apollo-Soyuz Test Project in July, in August ATS-6 was shifted a third of the way around the world and began one year of experimental broadcasting to small receivers in 2400 villages in India, featuring educational, agricultural, and health programming developed by the government of India.

The burgeoning use of communications satellites and the rapid growth of the technology have strained the number of available channels in the radio spectrum, as well as the international political and technical entities that control the allocation of this scarce resource. Major international conferences were called for the late 1970s to update the political and technical agreements. Both the Office of Telecommunications Policy of the Executive Office of the President and the Federal Communications Commission were heavily involved in gathering information and otherwise preparing for these meetings. NASA stepped up its experiments on possible ways of increasing the number of available channels in the higher regions of the radio frequency spectrum; and the United Nations began debate on international rules for direct broadcasting by satellite to home TV receivers.

An agreement for an experimental international aeronautical communications and positioning satellite (Aerosat) to improve air traffic control over the North Atlantic had been signed in 1974 by the Department of Transportation for the U.S., the European Space Agency (ESA) for Europe, and Canada. This year the AEROSAT Council met four times, reviewing progress and reevaluating the increasing costs of the space segment. Slightly less advanced in planning was INMARSAT, the proposed International Maritime Satellite System. Discussions generated by the Office of Telecommunications Policy were centered on organization of international participation and direction of such a system and on the desirability of U.S. participation.

Earth Applications

The use of experimental Earth-survey satellites to explore the potential benefits of space-based remote sensing systems continued. The second Earth-resources survey satellite, Landsat 2, was launched in 1975 to test the capability for providing remote sensing data from space and to explore the potential uses of these data in activities such as measuring and monitoring the world's food, timber, and water resources; locating mineral and fossil fuel deposits; and land use planning. The Geodynamic Experimental Ocean Satellite, Goes 3, was launched in April to supply data to experiments in measurement of ocean topography and solid-Earth physics. Development progressed on two satellites which will refine these investigations, Lageos (Laser Geodynamics Satellite) and Seasat. A small satellite, HCMM (Heat Capacity Mapping Mission), is under development to make a thermal map of the Earth's surface.

Various governmental agencies and industries continued to participate in the investigation of potential applications of Earth-survey satellites. NASA, the Department of Agriculture, and the National Oceanic and Atmospheric Administration (NOAA) moved into the second phase of the Large Area Crop Inventory Experiment (LACIE). By expanding on the available technology base, LACIE represents an experimental system for demonstrating the use of Landsat data for crop production inventory over large areas in a "quasi-operational" environment. The expected accomplishments of LACIE will be the development and testing of the technology required for the implementation of an operational satellite system for global crop monitoring and an assessment of the cost-effectiveness of such an operational system. The first phase of LACIE explored the possibilities of using Landsat data to inventory the U.S. wheat crop. The second and third phases will extend the investigation to other areas.

The Department of Interior, through its Geological Survey, made significant advances in computer manipulation of satellite imagery, including enhancement of Landsat images for use in geological research. Computer analysis of both digitized graphics and original Landsat digital data is being evaluated for potential use in systems that gather and report information on natural resources, geography, and basic-resources inventories. In another project, the Department of Agriculture used NOAA environmental satellite data in the control of the screwworm population in the southwestern U.S., where these grubs have long been a major destroyer of animals, especially cattle.

NASA, NOAA, and EPA continued their investigations of experimental use of satellite data to identify sources, type, extent, and potential effect of various kinds of pollution, both in the atmosphere and in the waters of lakes, streams, and oceans. A joint project was conducted in the New York Bight and another in the ocean area off Philadelphia where municipal sewage sludge is dumped. In the western U.S., EPA experimented with satellite and aircraft monitoring of the effects of new mining activities, particularly strip mining.

Other investigations of the potential use of data from Earth-resources satellites continued with some of the investigations in less immediately obvious applications. The Census Bureau of the Department of Commerce used satellite data in demographic studies both in the U.S. and overseas. The Environmental Protection Agency (EPA) is using satellite and aircraft data to map noise-polluted areas around six major municipal airports. The Geological Survey improved its streamflow estimates by use of Landsat data. In all, some 300 separate investigations have been or are in progress to explore the potential benefits and cost-effectiveness of Earth-resource data in a wide variety of information needs.

Man in Space

The one manned spaceflight in 1975 was the U.S.-U.S.S.R. Apollo-Soyuz Test Project (ASTP), to be discussed in the following section. ASTP was the last U.S. manned spaceflight scheduled until the Space Shuttle makes its first orbital test flight in 1979.

NASA's Space Shuttle continued development this year. Fabrication of all major components was on schedule and major assembly was proceeding. Rollout of the first orbiter vehicle is scheduled for September 1976.

International Cooperation

Apollo-Soyuz Test Project. The Apollo-Soyuz Test Project (ASTP) was the largest international cooperative space exploration project to date. For three years technical teams of American and Soviet engineers had worked closely together in planning the mission, developing the docking hardware, laying out the mission operations, and agreeing on joint experiments. In July 1975 the Soviet Soyuz spacecraft with two cosmonauts aboard was boosted into Earth orbit; seven hours later an American Apollo spacecraft with three astronauts was launched from Kennedy Space Center to catch up with the orbiting Soyuz. Rendezvous and docking were successful, with the crew moving from one spacecraft to the other, and performing joint experiments.

Spacelab. The European contribution to the total Space Transportation System, the Spacelab, was on schedule in 1975. Spacelab is intended to serve as a pressurized laboratory, to be transported in the cargo bay of an orbiter, where non-astronaut scientists can perform their experiments in shirtsleeve conditions. Another configuration is designed to provide instrument pallets open to outer space, where the instruments can be exposed directly to the space environment. In addition, Canada in 1975 agreed to join the Space Shuttle team and made commitments for a $30 million investment in development of a Remote Manipulator System to emplace and retrieve orbital payloads for the Space Shuttle.

Other highlights of the international program included three launches for other nations in 1975, the signing of three agreements for launch of future satellites, the beginning of the year-long experiment with India for instructional broadcasting by satellite to 2400 Indian villages, and the signing of three new agreements for foreign remote-sensing receiving stations for the Landsat program.

Defense

The Department of Defense made significant progress during 1975 in space activities. Development of the NAVSTAR Global Positioning System is proceeding on schedule, with work going forward on user equipment and prototype NAVSTAR satellites. When operational, NAVSTAR will make available precise data on user position and velocity, enhancing the military forces' capabilities for enroute navigation and position fixing. Until then, the current navigation satellite system (TRANSIT) continues to provide reliable, worldwide, two-dimensional position fixing.

The Defense Satellite Communications System (DSCS) provides global communications support for the World Wide Military Command and Control System. In 1975 two Phase II DSCS satellites failed to achieve proper orbits after launch but the system maintained limited operations through shared use of the NATO II-B and United Kingdom Skynet satellites. The Navy Fleet Satellite Communications System was authorized to procure its first flight-model spacecraft. Air Force and Army satellite communications efforts were advanced by successful tests of their ground terminals.

In other space activities, the Department of Defense chose a solid-propellant concept for validation and for development as the Interim Upper Stage, to be used with the Space Shuttle for extended-range missions where payloads need to be placed in higher orbits than the Space Shuttle alone can achieve. Finally, the Defense Meteorological Satellite Program continues to provide important weather data to all military services in support of operational forces.

Aeronautics

Aeronautical research and development have over the years contributed to the improved speed, comfort, and safety of commercial aircraft. In recent years, increased concern for the protection of the environment and for energy conservation has prompted a refocusing of research into the reduction of aircraft noise, emissions, and fuel consumption, in addition to the continuing research on improving aircraft safety, airport terminal operations, and the air traffic control system.

Improvement of Current and Future Aircraft

After several years of research in a number of disciplines, in 1975 NASA reported a systems approach to improvement of current commercial transport aircraft that would lessen the size and intensity of the aircraft noise level around airports and reduce emissions of engine-exhaust pollutants in both low- and high-power operations. Advanced research continued to define the elements of the next generation of long-haul and short-haul aircraft. A multi-faceted effort led to the formulation of a combination of improvements that have the potential of reducing fuel consumption of future commercial aircraft by a total of 50 percent. NASA and the Air Force jointly studied the design of a hypersonic research aircraft which would flight-test new developments in structural panels for hypersonic flight and assess the potential of scram-jet engines. In the field of short-haul aeronautics, NASA studied industry proposals to modify a C-8 Buffalo aircraft for flight-test of a short-haul engine having an upper-surface-blowing system for propulsive lift. DOT, DOD, and NASA studied the equipment and systems feasibility of using short-haul aircraft to supplement ground transportation in low and medium density intercity travel.

Improvement of the Operating Environment

A number of independent and joint programs of DOT's Federal Aviation Administration and NASA continued work designed to improve safety and operational efficiency of airway operations. These included research on reducing wake vortices that trail behind aircraft in airport traffic patterns, studies of fire-retardant materials for aircraft, analysis of human error in aircraft accidents, and improving airport terminal operations. Other research continued investigations of short-takeoff aircraft, supersonic-cruise aircraft, and improvement in aircraft control systems. FAA's modernization of the airspace system was completed, with new equipment installed at all air route traffic control centers and at the 61 busiest airport terminals.

Defense

Several important milestones were reached in military aeronautics in 1975. The first prototype B-1 bomber completed a year of flight testing, which included supersonic flight and aerial refueling. Congress approved funds for the production of six E-3A aircraft for the Airborne Control and Warning System. The Air Force selected the F-16 as its air combat fighter to complement the F-15. The F-15 completed its evaluation of the YCH-53E helicopter and the F-14 compiled the most successful fleet introduction [illegible] of any Navy aircraft. The F-14A will be joined in the future by the F-18, which the Navy selected to be its air combat fighter. The A-10 close-air-support aircraft completed its final preproduction tests with excellent results.

The first prototype of the Air Force Advanced Medium Short Takeoff and Landing Transport made its first flight in 1975, while the second prototype is scheduled for flight testing in 1976. The Navy completed its evaluation of the YCH-53E helicopter and was authorized to fabricate two pre-production prototypes. The Advanced Attack Helicopter program is proceeding through the first phase of development, which includes ground and air tests.

In aeronautical research, experiments by the three services indicate that substantial weight savings can be achieved with no loss in performance when standard metal parts are replaced by composite parts. Improved combustor concepts for the reduction of engine emissions have demonstrated reductions on the order of 50 percent.

During 1975 the Department of Defense and NASA participated in many cooperative efforts. The Aeronautics and Astronautics Coordinating Board (AACB) is the principal formal coordinating body between DOD and NASA. Last year the AACB concluded that a single National Transonic Facility was feasible; recommended the construction of the Aeropropulsion System Test Facility (ASTF); and found Vandenberg AFB to be a more effective and less costly west coast landing site for the Space Shuttle than Edwards AFB. The Tilt Rotor Research Aircraft, a joint Army-NASA product, will be ready for testing early in 1976. Finally, the first flight of the Rotor Systems Research Aircraft, another Army-NASA development, is scheduled for July 1976.

Details of the activities summarized here are presented in the chapters that follow.

II

National Aeronautics and Space Administration

Introduction

The National Aeronautics and Space Administration (NASA) is the civilian agency of the United States government charged with planning, direction, and conducting research and development activities related to civilian space and aeronautics programs. In carrying out these responsibilities, the agency works with many other civilian Federal agencies that have research or operational interest in these fields and also interacts with and provides research and development assistance to the Department of Defense, which conducts the military space and aeronautics program.

In its space program, NASA has since its inception in 1958 pursued several broad goals: development of technology for space operations, demonstration of practical applications of space systems and technology, and discovery of new scientific knowledge about the origin, evolution, and processes of the universe, our solar system, near space, and the complexities of the Earth's atmosphere. While emphasis has fluctuated from time to time, the broad intent has remained constant.

In 1975 NASA made significant gains in both space and aeronautics. In space, NASA orbited 19 satellites, the largest number in several years. Many of these spacecraft, as well as others launched in previous years, produced useful information. The successful U.S.-U.S.S.R. docking flight in the Apollo-Soyuz Test Project and the launches of Viking 1 and 2 were the most visible highlights in a year of diversified and intense activity In aeronautics, a major study of several years' research results in various disciplines identified technology efforts that, taken together, could reduce fuel consumption of commercial aircraft by as much as 50 percent, with attendant reductions in emission of pollutants and in noise. These and other aeronautical technology advances typified the achievements in 1975.

The succeeding pages describe the details of NASA's space and aeronautical program and progress in the year just ended.

Study of the Universe and the Sun-Earth Relationship

The NASA physics and astronomy program is directed toward the investigation of the Earth, the Sun and the solar system, galactic and extragalactic phenomena, and how they interrelate. To achieve the program objectives, the techniques used include theoretical and laboratory research, aircraft, balloons, sounding rockets, small Explorer spacecraft, large automated observatories, and manned spacecraft. Research teams are located at NASA field centers, other government laboratories, universities, and industrial laboratories. NASA also conducts a number of cooperative projects with foreign countries.

Significant accomplishments of the program during 1975 included the launches of the Orbiting Solar Observatory (OSO-8) to study solar phenomena, Small Astronomy Satellite-C (Explorer) to conduct X-ray studies of galactic and extragalactic sources, and Atmosphere Explorers D and E to investigate Earth's lower atmosphere. Several significant scientific experiments were also conducted on the Apollo-Soyuz mission. The NASA Airborne Observatory, with its 91-centimeter telescope, became operational and made several meaningful discoveries. The sounding rocket and balloon programs also made important scientific contributions.

Study of the Universe

Orbiting Observatories. The Orbiting Astronomical Observatory-3 (OAO-3, also named Copernicus), which was launched in August 1972, continued to obtain scientific data during 1975. Its primary objective has been to obtain high-resolution ultraviolet spectra of the stars with which to investigate the composition and physical state of matter in interstellar space and stellar sources. More than 14,000 observations of 309 unique celestial objects have been made using the University College London X-ray telescope.

Astronomers from the University of Colorado and the Johns Hopkins University, using ultraviolet instrumentation on the Copernicus satellite, discovered the first evidence of the presence of a corona (region of high-temperature gas) surrounding a normal star other than the Sun. The temperature of this corona (about 260,000 kelvins) was less than expected from current theories explaining the heating of the solar corona. This discovery introduced the possibility of performing comparative studies of the coronas of stars with varied surface temperatures, luminosities, and ages, for a greater understanding of basic coronal physics, possible evolution of the solar corona, and nature of the long-term interaction between the Earth and the Sun.

The OSO series of spacecraft has not been restricted entirely to solar studies, but has acted as host for other disciplines. OSO 8, launched in June, continued this tradition and carried four experiments to search for celestial X-ray sources. X-ray spectra of two stellar objects, Cen A and Sco XI, and spectra in the 2 to 60-keV range were obtained for more than 20 of the sources identified by the Uhuru satellite. Studies were made of the galactic X-ray background radiation and of the polarization of stellar X-ray emission. The distribution and variability of helium and hydrogen were studied in the terrestrial atmosphere and in the interplanetary medium.

Small Astronomy Satellite. In May the last of the Small Astronomy Satellites, SAS-C, was placed into an equatorial orbit by an Italian launch crew from the San Marco Facility off the coast of Kenya, Africa. Many new questions were posed as a result of the success of the previous SAS-A mission (Uhuru) and other X-ray satellites such as ANS (an international cooperative project with the Netherlands) and UK-5 (another cooperative project with Great Britain), sounding rockets, and coordinated and correlative observations in the X-ray, optical, and radio spectra. The accumulation of information and significance of results necessitated many more observations with higher spatial and energy resolution, over broader spectral range, with more precise source position accuracies and finer temporal resolution. SAS-C, with its complement of four X-ray instruments, is the most powerful X-ray mission yet flown. It obtained significant new results on the properties of many specific galactic and extragalactic X-ray sources. In August 1975 SAS-C discovered the most intense X-ray source ever observed, believed to be a recurrent nova. This source had a peak X-ray intensity five times that of Sco X-1, which had been the most intense known. After SAS-C located the source accurately enough to enable observations by ground-based optical and radio observatories, the source was identified optically. The degree of optical brightening was almost 100 times that during the quiescent change phase.

Helios. Helios, a cooperative space project between the Federal Republic of Germany and the United States, has as its general scientific objective providing increased understanding of fundamental solar processes and solar-terrestrial relationships. Helios-A was launched by a Titan-Centaur on December 10, 1974, and Helios-B is scheduled to be launched in 1976. They will travel more than two thirds the distance from the Earth to the Sun—closer to the Sun than any previous spacecraft. Germany built the spacecraft and seven of the experiments; the United States provided three experiments, the launch vehicles, launch and flight operations support, and technical support. During 1975, assembly and test of Helios-B was completed, and analysis of the Helios-A data was started.

High Energy Astronomy Observatory (HEAO). The basic scientific objective of the High Energy Astronomy Observatory Program is to explore the previously inaccessible regions of celestial X-ray and gamma-ray sources and of cosmic-ray flux. This program should increase our understanding of newly discovered energy processes, of the creation of matter, and of observed phenomena such as quasars, pulsars, novae, supernovae, and black holes. The first phase of the HEAO program consists of three satellites to be launched on Atlas-Centaur rockets; larger observations are being studied by NASA as possibly payloads to be launched by the Space Shuttle. Considerable progress was made during 1975 in the design, development, and fabrication of the first three spacecraft and experiments, with primary emphasis on the HEAO-A mission.

International Cooperative Satellites. Work continued on the International Ultraviolet Explorer (IUE), a joint project between NASA, the United Kingdom, and the European Space Agency (ESA), planned for launch in FY 1977. Detailed design reviews were completed and hardware was procured for this international orbital telescope facility; and fabrication of the flight telescope and spacecraft began.

Progress in another joint project, the International Sun-Earth Explorers (ISEE), included completion of major procurements, detailed design review of the A and B spacecraft and experiments, and completion of contract negotiations with all experimenters. Three spacecraft, two provided by NASA and one by ESA, with a combination of instruments from both NASA and ESA, will be used on the mission. ISEE goals include the study of the Earth's magnetosphere, effects of the solar wind on the magnetosphere, and interaction of cosmic rays with the solar wind and magnetosphere.

Space Telescope. The study of astronomical objects requires telescopes of the largest collecting area and the highest resolution possible. During 1975 NASA studied a proposed 2.4-meter high-resolution Space Telescope which would provide enhanced capability to observe galaxies and objects at greater distances than those that can be seen using the largest Earth-based telescopes. The Space Telescope, which is designed to be placed in a low Earth orbit by the Space Shuttle, would be operated as a national facility, providing continuous coverage in wavelengths from the far ultraviolet to the near infrared. Scientific instruments would explore the universe and observe both stellar and galactic phenomena. Significant contributions are expected from the study of early stages of star formation and from observations of such highly evolved objects as supernova remnants and white dwarfs.

Sounding Rockets, Balloons, and Aircraft. The sounding rocket program launched 65 rockets from sites in the United States (Wallops Flight Center, White Sands Missile Range, Poker Flat, and Hawaii), Canada (Ft. Churchill), Sweden, Norway, and Kerguelen Island and supported about 50 research teams from universities, private industry, foreign governments, NASA field centers, and U.S. government agencies. A coordinated program in Peru near the geomagnetic equator involved 30 sounding rocket launches and observations from balloons and aircraft. These equatorial stratospheric and ionospheric observations were correlated with the Jicamarca backscatter radar on Atmospheric Explorer. Gravity Probe-A, involving an extremely accurate hydrogen maser clock to measure the relativistic effects predicted by Einstein, was developed for launch in 1976.

The NASA balloon program launched 40 balloons from the United States and Canada and supported 20 research organizations. The balloon is a cost-effective way of conducting research, and this has been recently reaffirmed by important scientific discoveries, including the infrared measurement of objects not detectable by satellites or radiotelescopes, a far-infrared celestial survey along the galactic plane, and detailed mapping of complex cold gas regions in which stars are being formed.

The NASA airborne science program utilized two aircraft for astronomical research at altitudes above 90 percent of the Earth's atmosphere. The C-141 aircraft, with its 91-cm infrared telescope, was designated the Kuiper Airborne Observatory and began operational flights in 1974. Initial results included the discovery of water vapor on Jupiter and the discovery of the "Egg Nebula," believed to be a solar system in the process of formation. The NASA Lear Jet, with its 30-cm telescope, continued significant infrared research.

Study of the Sun

Orbiting Solar Observatories (OSO). OSO 8, the last and largest satellite in this Observatory series, was launched into an orbit 550 kilometers above the Earth in June. Its primary objective is to study the hot outer layers of the Sun at a time in the solar cycle when they are least disturbed. The structure and composition of the solar chromosphere and low-transition region, where the temperature rises suddenly from about 4200 to more than 100,000 kelvins, are being studied by two high-resolution spectrometers. Accurate measurements are being made of material motions and oscillations in different solar features, allowing a better understanding of the heating mechanisms responsible for the increase in temperature. Knowledge of the variability of the ultraviolet and extreme ultraviolet radiation selectively emitted at these temperatures is important from a terrestrial viewpoint because this radiation interacts with the Earth's atmosphere, forming the ionosphere and ozone layer.

Even at "solar minimum," some active regions occur on the Sun. The ultraviolet spectrometers and two X-ray spectrometers, mounted in the wheel of the satellite, conduct studies in active regions of the variations in conditions as a function of time in their evolution. Investigations of energy transport mechanisms in sunspots are of special interest.

Apollo Telescope Mount (ATM). Data collected by Skylab astronauts with the six major solar ATM telescopes flown in 1973-1974 were in full analysis in 1975. Participation by outside scientists increased as a result of the ATM guest investigator programs and a series of Skylab Solar Workshops was initiated to further encourage participation.

High-resolution ATM observations of coronal holes, at all heights in the solar atmosphere, permitted the investigation of their properties. These solar features were confirmed to be cool regions of open magnetic-field configuration, apparently the source of recurrent high-velocity streams in the solar wind. ATM observations revealed two new properties: (1) holes maintain a signature down to lower levels in the solar atmosphere than previously had been realized; and (2) certain holes seem to rotate as rigid bodies rather than displaying the normal latitude-dependent differential rotation. The significance of these discoveries will be considered in the first Skylab Workshop, which will offer a detailed survey of these features.

Prominence activity, identified as the source of most coronal transients, solved a long-standing problem in solar wind disturbances. Comparisons of the density and energy properties of coronal transients, as observed by the white light coronagraph on ATM, with corresponding properties measured several days later by Pioneer 10 have increased our understanding of disturbance propagation through the interplanetary medium. This work will be extremely beneficial in predicting the effect on the Earth of solar disturbances.

The variability of ultraviolet and extreme ultraviolet emission from different quiet solar features was defined by means of ATM observations. The output of these radiations from the quiet Sun, found from the ATM to be variable as a function of time, could have important solar-terrestrial implications.

Solar Maximum Mission (SMM). In contrast to OSO 8, predominantly devoted to studies of the quiet Sun, plans were formulated for detailed investigation of flares and other manifestations of solar activity during the active Sun period in 1979-1980. So it can observe the greatest possible number of flare events, the SMM is scheduled to be launched at the peak of activity in the forthcoming cycle, which is estimated to occur in 1979-1980. About eight instruments, designed to investigate all aspects of a flare, would be carried.

Exploration of the Planets and the Moon

Investigations of the planets and the Moon continued during 1975 to provide further understanding of the nature, origin, and evolution of the solar system, and particularly the Earth.

The Inner Planets

Viking Mars. Two Viking spacecraft (each consisting of an Orbiter and a Lander) were launched in the late summer of 1975 by Titan-Centaur vehicles. Both spacecraft are now on their planned trajectories to Mars and are performing satisfactorily.

Viking 1 will be inserted into orbit in June 1976; planned landing sites will be evaluated for about two weeks before the Lander is placed on the Martian surface in July to conduct scientific experiments for about 60 days. Viking 2 will land at a different site in September and will also conduct experiments for 60 days.

The basic Viking mission will end in November 1976 after providing data about the existence of life on Mars and gathering information to help scientists understand the evolution of Mars and the solar system. Results derived from these spacecraft, the first NASA spacecraft ever to land on another planet, will provide information regarding the origin of life and how life interacts with a planetary environment.

NASA plans to conduct an extended mission to observe seasonal changes, at a much reduced level of effort, after completion of the basic mission. The extended mission will end about September 1978.

Mariner Venus/Mercury 1973 (MVM '73). The Mariner 10 spacecraft completed a third flyby of Mercury on March 16, 1975, at a distance of only 327 km from the planet's surface. This close trajectory was selected to achieve the major objective of the third encounter, investigation of Mercury's magnetic field. In addition to learning of the existence of a weak intrinsic magnetic field, scientists determined that the magnetosphere of Mercury is remarkably similar in structure to that of the Earth. Mariner 10 also took about 300 quarter-frame TV pictures, some of the best resolution (about 50 meters) pictures produced throughout the mission.

Following engineering tests, which overstressed various spacecraft subsystems to obtain data on flight anomalies and limits for future missions, the spacecraft ran out of attitude control gas and was commanded to turn off its transmitter for the last time on March 24, 1975.

In addition to these significant discoveries, Mariner 10 was the first spacecraft to use the gravitational field of one planet to reach and explore another. It obtained the first close-up TV pictures of Venus and Mercury; discovered the fast rotating clouds of Venus; revealed the thin helium atmosphere, weak magnetic field, and temperature gradients of Mercury. It also completed both the basic and extended missions below the cost projections established five years earlier.

Pioneer Venus. The Pioneer Venus project began in FY 1975 and included detailed design and necessary development testing. The objectives of the mission are designed to further improve our understanding of the origin and evolution of the solar system. The primary goal is to obtain a detailed characterization of the Venusian atmosphere, which in turn will provide information that could help scientists to understand the atmosphere of Earth.

Two flights are planned: one will make *in-situ* measurements at multiple locations on Venus with atmospheric entry probes; and the other, an orbiter mission, will provide data on a planetary scale. The spacecraft will be launched by Atlas-Centaur launch vehicles in 1978.

Outer Planets

Pioneer Jupiter. Pioneer 10 began the close exploration of the outer planets when it completed its successful flyby of Jupiter in December 1973. As Pioneer 11 was launched one year after Pioneer 10, there was sufficient time to examine the Pioneer 10 data and then to select a target point for Pioneer 11 that best augmented the data. The point selected provided excellent data on Jupiter and also modified the spacecraft trajectory in a way that will take it to Saturn in 1979. Pioneer 10 meanwhile continues on its flight out of the solar system.

The 1975 analysis of the data from Pioneer 11, which completed its successful flyby in December 1974, provided a much better understanding of Jupiter, its atmosphere, and especially its field and particle environment.

Mariner Jupiter/Saturn Mission. During 1975 the detailed sub-system design of the Mariner Jupiter/Saturn 1977 (MJS '77) spacecraft was completed. Subsystems and science instrument hardware were fabricated and tested, and assembly of the test-model spacecraft was initiated in preparation for structural and temperature-control tests. Work on mission operations software and ground-based hardware was initiated.

The project consists of two Mariner-class spacecraft to encounter Jupiter in 1979 and Saturn in 1981. In addition to photographs, scientific studies will be made of Jupiter and Saturn, including their satellites and the rings of Saturn, as well as of the interplanetary and interstellar media. Observations will be made of the planets' mass and density, atmospheric composition and circulation, magnetic field, and exposure to solar radiation.

Lunar Science

Studies of the Moon over the past decade produced large amounts of new data that not only increased our knowledge of the Moon but also added new dimensions to our understanding of the earliest events in the history of the Earth, where the geological record of the first billion years has been destroyed. These data provided new facts about the long-term history of solar radiation with possible major clues to long-term trends in the Earth's climate, and even the events causing the ice ages. Continuing lunar studies provide deeper insight into the evolution and interrelationships of the entire solar system.

Radioactive dating of the lunar mare basalt samples returned to Earth showed that they all originated as lava flows about 3.1 to 3.8 billion years ago. Further analysis showed that they were all derived from a source region that had been chemically isolated 4.4 billion years ago, implying a planetary-wide geochemical separation of the Moon's crust from the deeper mantle at that time. This evidence has brought scientific understanding still closer to the earliest events nearly 4.6 billion years ago, when both the Earth and the Moon were formed.

The use of the Moon as an interplanetary probe into time and space took a major advance when ion microprobe measurements showed significant variations with depth of ions implanted at different energies into the surfaces of individual lunar soil grains. This means that soil samples from different depths, cores, and ages can extend the detailed history of solar activity over billions of years.

Impact-produced glass (agglutinates) in lunar soils are significantly enriched in some elements (iron, magnesium, sulfur, phosphorus, etc.) and depleted in others (calcium, aluminum, europium, etc.) in comparison with the bulk soil composition. The mechanisms of this effect have not yet been clearly established; however, spectral measurements of the planet Mercury suggest that a similar process may exist there.

Accurate determination of the lunar moment of inertia from observations of Explorers 35 and 49 produced evidence that the Moon has a small, dense core. This important discovery provided information needed to understand the geological evolution of the Moon and the possible existence of an early, but now vanished, magnetic field.

Laser ranging measurements from observatories on Earth (three in the U.S. and one in the U.S.S.R.) to the lunar retroreflectors are continuing as scheduled. During 1975, the first such measurements were made from the newly opened station on Mt. Haleakala, Hawaii, to determine baseline distances on Earth, and to help refine measurements of the relative motions of the Earth and Moon. Changes in long baseline distances on Earth measure movements of the lithospheric plates (plate tectonics), which are also the causes of earthquakes and of ore deposits.

During 1975, five of the Apollo Lunar Surface Experiment Packages placed on the Moon between 1969 and 1972 continued to return significant data on lunar phenomena, including moonquakes and meteor impacts.

Life Sciences

Recognizing the importance of the science aspect of Life Sciences, and especially the anticipated role of Life Sciences in the Space Shuttle/Spacelab payloads, NASA transferred the Life Sciences program from the Office of Manned Space Flight to the Office of Space Science. The Life Sciences Supporting Research and Technology Program has been reoriented to emphasize research that will explain the physiological mechanisms underlying the changes observed in human physiology during the Skylab flights.

Preparation of Life Sciences payloads for inflight investigations in the Space Shuttle/Spacelab era began. "An Invitation to Participate in Planning the NASA Life Sciences Program in Space" was mailed in May 1975 to a large segment of the Life Sciences community, resulting in over 1400 responses by the end of September 1975.

In anticipation of the need to provide medical support to orbiter crews, a prototype system for the delivery of health care has been developed. This system includes use of two-way video communication, advanced data management techniques, and extensive use of paramedical personnel. To evaluate the medical acceptance of this concept, NASA and HEW are conducting a two-year operational field test of the system at a remote site, the Papago Indian Reservation in Arizona. During the first six months of this field test, approximately forty patients per day have been treated, with a high degree of acceptance by both the patients and the medical and paramedical personnel.

At the fifth meeting of the U.S.-U.S.S.R. Space Medicine and Biology Working Group at Tashkent, U.S.S.R., in October-November 1974, the Soviets offered NASA Life Sciences an opportunity to participate in the experiments on the Kosmos Biological Satellite. Subsequently, the U.S. proposed to fly four experiments on the Kosmos; these were accepted by the U.S.S.R. and were launched by the Soviets in December 1975.

Study of the Earth's Atmosphere

Atmospheric Explorer Satellites

The last two Atmospheric Explorers (AE-D and E) were launched in October and December 1975, respectively. AE-D (Explorer 54) was placed in polar orbit and AE-E (Explorer 55) into a low-inclination orbit to provide coordinated global studies of the upper atmosphere. The spacecraft are collecting data relating solar ultraviolet radiation to atmospheric composition in the lower thermosphere, where most chemical and energy conversion processes that govern the structure and properties of the upper atmosphere occur. Measurements are also being extended to regimes down to altitudes below the upper atmosphere, where most of the solar extreme-ultraviolet radiation is absorbed.

Upper Atmospheric Research

In 1975 Congress included in NASA's FY 1976 authorization bill a section assigning to NASA the responsibility for conducting research in the upper atmosphere. NASA established an Upper Atmospheric Research Office, consolidated research previously conducted on the stratosphere by other NASA offices, and initiated an expansion of the research effort. The long-term goal is to develop a better understanding of the physical and chemical processes occurring at the level of the upper stratosphere. For the short term, the resources are being used to assess the effects on the amount of ozone in the stratosphere from chlorofluoromethanes, Space Shuttle effluents, aircraft effluents, and other chemicals.

There were several positive results in 1975. The assessment of ozone reduction that would be caused by Space Shuttle operations was reduced by a factor of three and the uncertainty factor of the data was also reduced. This research is continuing. Since the amount of ozone in the stratosphere is known to fluctuate, it is difficult to ascertain how much ozone depletion is caused by its interaction with effluents and other chemicals and how much from "natural" causes. Therefore, much of the research attacks the problem indirectly by measuring the amounts and types of chemicals that are present at that height. A research balloon was sent into the stratosphere with equipment using the resonance fluorescence technique and measured the amount of OH radical. A NASA U-2 aircraft measured the vertical profile of stratospheric hydrogen chloride, using an interferometer.

New projects undertaken in 1975 added fluorocarbon measurement equipment in the U-2 and in three of the commercial airliners participating in the Global Air Sampling Program. Support has begun for research that will make other important measurements of stratospheric chlorine, hydrochloric acid, and fluorocarbons.

Applications to Earth

The objective of the Applications program is to identify potential applications of space-related technology which could make substantive contributions to solving national, as well as international, problems and needs. The program includes investigations in areas such as ecology, population, weather and climate, communications, food production, hydrology, energy, and natural resources.

In 1975 the Applications program had five successful launches of satellites which provide continuous data in the areas of Earth Resources Survey (Landsat 2), Weather and Climate (SMS-2, Nimbus 6, Goes 1), and Ocean Dynamics Research (Geos 3).

The Applications Technology Satellite, ATS-6, completed more than one year of successful operations, demonstrating the use of satellites in broadcasting educational and health information to people in remote areas. ATS-1, 3, and 5, earlier experimental communications satellites, were still in limited service for certain kinds of experimental data and communications. The first Earth-resources satellite, Landsat 1, continued to provide Earth-resources data but with data transmission limited to those times when it was in line of sight of a ground receiving station. Of the earlier weather satellites, SMS-1 and NOAA 3 and 4 were fully operational. Essa 8 and Nimbus 4 and 5 were still capable of limited data collection.

Earth Resources Survey

The Earth Resources Survey Program involves the application of space or space-related remote sensing systems to the measuring and monitoring of parameters associated with agriculture, forestry, rangeland management, minerology, marine and inland water resources, cartography, land use and urban development, and geology.

During 1975, the Earth Resources Technology Satellites (Landsat 1 and 2) continued to acquire new data and, along with extensive data from the Earth Observations Aircraft Program, were used to further develop and demonstrate our measurement and monitoring capability.

Earth Resources Technology Satellites. Landsat 1, launched July 23, 1972, has been a successful experimental mission and has provided data for more than 300 specific investigations. In addition, Landsat 2, launched on January 22, 1975, is operating satisfactorily. Several potential applications have been identified from the investigations:

- Measurement of agricultural acreages and use of such data with yield data for crop estimates;
- Monitoring of timber and forestry resources;
- Surveillance of grazing land to improve range management;
- Incorporation of land-use data in state and regional inventory systems and in environmental impact assessments;
- Water resources applications in watershed mapping, snow mapping and monitoring, flood plain mapping, detection and monitoring of lake and sea ice, and surface-water mapping;
- Reductions in cost and savings in time for mineral and oil exploration;
- Collection of marine resources data for use in coastal zone management; and
- Environmental applications such as monitoring of mines, and the impact of man's activities on wildlife habitat.

Applications Demonstrations. Demonstrations this year include a Large Area Crop Inventory Experiment (LACIE) concentrating on wheat production estimates, satellite snow-cover observations for water-runoff estimates, a natural resources inventory system for the state of Mississippi, an environmental information system in south Louisiana for the Corps of Engineers, and a project with the Coast Guard to extend the Great Lakes winter shipping season by monitoring lake ice.

Weather and Climate

The Weather and Climate programs have the longest history among U.S. programs to apply space techniques and are primarily directed toward improving the accuracy of both short- and long-term weather forecasting.

Basic and applied research supported space-related experiments, satellite development, and operations of the National Weather Program. Activities also included the development and demonstration of new sensing techniques and atmospheric modeling techniques in support of the Global Atmospheric Research Program (GARP). The second Synchronous Meteorological Satellite (SMS-2) was launched on February 6, 1975, and joined the first member of the SMS series in acquisition of near-continuous imagery of the western hemisphere's cloud cover. SMS-1 continued to make major contributions to the success of GARP through the acquisition of important meteorological data over the Atlantic tropical region. A major new direction of the Weather and Climate program has been in the detection, prediction, and warning of short-lived, violent, and destructive storms. Stationed over the equator at 115°W, SMS-2, together with SMS-1, which was launched in 1974 and stationed at 75°W, provided continuous observational capability of the cloud cover over most of the western hemisphere. Each spacecraft is capable of taking complete Earth-disc pictures every thirty minutes day and night, extremely useful in detecting the formation of severe weather phenomena associated with tropical storms, hurricanes, and tornadoes. Data from these satellites were provided in real time to the National Weather Service, the Hurricane Center at Miami, and the Severe Storm Center in Kansas City.

The SMS satellites are the operational prototypes of the Geostationary Operational Environment Satellite (GOES) system managed and operated by NOAA. The first GOES satellite, successfully launched on October 16, 1975, signified the inauguration of the fully operational GOES system.

Global Atmospheric Research Program (GARP). A series of Data Systems Tests (DST), has been providing a simulation of the observing, data-collection, and data-processing system for the First GARP Global Experiment (FGGE) planned for 1978-1979. The fourth Data Systems Test (DST-4) was conducted in early 1975 and produced a 60-day global data set useful for studies in atmospheric sounder impact tests and included sea-ice and rain-rate data.

In August/September 1975, following the launch of Nimbus 6, DST-5 produced a summer global data set useful for four-dimensional simulation studies. The Tropical Wind Energy Conversion and Reference Level Experiment (TWERLE) obtained tropical wind and meteorological data from more than 100 balloons flying at a constant level near 14 kilometers and using Nimbus 6 for data collection and location. The Carrier Balloon System (CABALS) was tested during DST-5 and provided data from more than a dozen extra-large balloons flying at 24 kilometers. The balloons circled the tropical regions, each carrying over 50 dropsondes, which were released on command to obtain wind and meteorological data on their descent through the atmosphere.

DST-6 will assemble a complete global-data set during winter-time conditions. Buoys transmitting air-sea observational data through Nimbus 6 are a new addition to this DST.

As part of the national effort, NASA was assigned responsibility for planning of FGGE. In August 1975, the U.S. plan for participation in FGGE was forwarded to the Chairman of the Federal Committee for Meteorological Services and Supporting Research. The plan will be used for developing detailed implementation plans.

Pollution Monitoring

Water Pollution Monitoring. Man's disposal of many forms of waste has put the coastal waters and marine environment under ever-increasing stress. The waters of the New York Bight—an area extending from Cape May, New Jersey, to Montauk Point, Long Island—continued to be used for the dumping of dredge spoil, sewage sludge, and industrial wastes.

NASA, in cooperation with the National Oceanic and Atmospheric Administration (NOAA) and with Region II of the Environmental Protection Agency (EPA), evaluated the potential role of remote sensing through coordinated overflights and surface-truth measurements of the New York Bight. In addition to detecting the dumping and resultant dispersion, spectral signatures of the sludge and acid wastes were measured, as well as quantitative correlations of surface winds, temperature, salinity, sediment, and chlorophyll concentrations.

Earlier research had shown that remote sensing can detect algae blooms and, with spectral discrimination, give some indication of the algae color group. This promising work has led to a new emphasis, in cooperation with the Florida Department of Natural Resources, on determining the requirements for a remote sensor to detect red-tide blooms and to discriminate between the harmful, toxic red tides and the harmless algae types that also occur in the Gulf Coast waters. The Florida red-tide, *Gymnodinium breve*, is known to originate offshore. The overview provided by remote sensing is necessary for early detection and possible control action.

Tropospheric Monitoring. Emphasis in tropospheric monitoring research has been on developing remote-sensing techniques to measure tropospheric trace gases on a global scale and to define the capabilities to satisfy urban/regional-scale monitoring needs.

Oceanographic and Air Pollution. The Nimbus-G Oceanographic and Air Pollution Observing Satellite, to be launched in 1978, is a major element of the program. Its experiments are designed to provide data on air and water pollution, oceanography, the atmosphere/ocean interface, and the Earth's energy balance. Nearly 200 scientists and other data users responded to an Announcement of Opportunity for participation on Nimbus Experiment Teams.

As part of the continuing developmental program for the Coastal Zone Color Scanner experiment, a series of field tests led to selection of the optimum spectral bands for the satellite instrument. An airborne scanner with adjustable spectral channels was flown over ocean-dumped wastes from industrial plants, areas of high sediment concentration, and waters containing algal blooms to gather a wide range of spectral signature data on substances in coastal waters. Many of these flights were supported by correlation measurements to obtain surface truth.

Communications and Data Management

NASA's program in space communications continued to develop and demonstrate the technology needed to meet agency requirements for communications systems, to maintain the nation's position as a world leader in communications systems technology, and to fulfill statutory obligations to provide consultation and technical services to Federal agencies.

Applications Technology Satellite 6. ATS-6 successfully completed one year of U.S. operations on May 20, 1975, and performed many experiments involving broadcast of high quality, color television programming to small, inexpensive ground terminals. Also included were voice communications and position determination for ships and airplanes and broadcasts of educational, health, and medical information to people in remote areas in Alaska, Appalachia, and Rocky Mountain states. This year of experimentation was highly successful in demonstrating the widespread utility of high-powered broadcast satellites in supporting social needs of remote regions. After the first year's operations in the U.S., ATS-6 was moved to 35°E, arriving on station July 1, 1975. The first operations there provided television coverage of the Apollo-Soyuz Test Program mission. ATS-6 was the communications link that permitted live television coverage of the link-up of the two spacecraft and the meeting of astronauts and cosmonauts in space.

ATS-6 began support of the Satellite Instructional Television Experiment (SITE) on August 1, 1975. This one-year experiment is being conducted by the Indian Government to provide instructional television to about 5000 Indian villages. Areas of instruction include family planning, health and hygiene, agriculture, and national development. In August 1976, ATS-6 will be moved back to the U.S. to resume third-year experimental operations.

Communications Technology Satellite (CTS). CTS is a cooperative program between the Canadian Department of Communications and NASA. This experimental satellite will be launched early in 1976 to experiment with technology demonstrating satellite communications to low-cost ground stations in the 12-GHz frequency band. Experiments will encompass a wide range of educational, health, social services, and information-exchange investigations.

Advanced Communications Research and Technical Consultation. In 1975, research exploring the higher regions of the radio frequency spectrum was expanded. Studies continued on frequency allocation and bandwidth and orbit requirements for future missions. Investigations to open up new regions of the spectrum for applications were continued as were efforts to develop or improve space communication components and technologies. Technical consultation to the Federal Communications Commission, in evaluating satellite systems, expanded as more new applications for domestic and international satellite services were filed. Spacecraft design reviews for INTELSAT and the U.S. domestic communications satellite applicants continued.

A major effort in 1975 involved preparations for the World Administrative Radio Conferences to be held in 1977 and 1979. NASA provides technical support to the Federal agencies as they prepare the U.S. position.

Data Collection Via Satellite

Data collection experiments with new users expanded during 1975. Over 250 balloons and 20 buoys have been launched and are being tracked and their sensor data relayed to ground stations by Nimbus 6. Landsat 2 is collecting experimental data for use by the Department of Agriculture in predicting snow run-off, as well as flood-control information on a number of rivers and streams for the Geological Survey and the Corps of Engineers. Landsat 2 data have been completed and are being used by these agencies in the Mississippi and Louisiana regions.

Data Management. Data-information management moved ahead on several broad fronts. Users of space-derived data and designers of missions, platforms, sensors, and analysis techniques participated in the development of the total systems to ensure that objectives are met. Computer-based simulations of data-management configurations were under construction and will be examined in 1976.

Space Processing

This program is developing applications of space flight for applied research in all branches of materials science and technology and for processing in space products of high value to be used on Earth.

In 1975, analysis of the Skylab experiments on solidification and crystal growth was completed. The major results of these experiments were confirmed and extended by experiments on the Apollo-Soyuz Test Project (ASTP) mission. The latter experiments added significantly to the evidence that orbiting production facilities could have unique advantages for the growth of electronic crystal materials from molten materials, vapor phases, or solutions. In addition, the ASTP mission carried two experiments on the preparation of pure strains of living cells by a process known as electrophoresis. These space-based experiments produced purer cell preparations than those produced on Earth and returned the cells alive for culturing and scientific evaluation.

The Space Processing Program studied specifications for Space Shuttle payload equipment and began a series of ballistic rocket flights in 1975 to continue experimentation until the Shuttle becomes available.

Earth and Ocean Dynamics Applications Program (EODAP)

EODAP is directed toward the design, development, demonstration, and use of space-derived techniques for observation of dynamic motions of the Earth and for monitoring and forecasting ocean surface conditions on a global, near real-time basis. The Earth Dynamics portion is aimed at the measurement of crustal motions near earthquake fault zones and detection and analysis of anomalies in the motion of the Earth's pole and rotation rate, which are believed to be associated with certain earthquakes. Measurements are derived from very accurate ranging to satellites with tracking instruments and from an analysis of the emissions of distant radio stars as they are received simultaneously at two or more tracking stations. The Ocean Dynamics portion is directed toward measuring and predicting ocean surface conditions, including wave height, temperature, and wind, as well as determining tides and mapping ocean currents and circulation.

On April 9, 1975, the Geodynamics Experimental Ocean Satellite (Geos 3) was successfully launched. This spacecraft, equipped with a radar altimeter, will be used for ocean studies; laser-ranging-cube corners will also support very accurate polar motion determination.

Preparations neared completion for the launch in early 1976 of the Laser Geodynamics Satellite (Lageos), the first satellite specifically designed for laser ranging to determine crustal motion parameters.

Procurement was begun in 1975 for the spacecraft and sensors for the Seasat-A mission. Seasat-A, to be launched in 1978, will carry a set of active and passive microwave devices for joint NASA/user-agencies studies of sea state, ocean currents, and the air/sea boundary.

User Affairs

The User Affairs office identifies user needs; disseminates information to potential users of NASA's space systems; and plans and monitors technology transfer programs in the space applications area.

A cooperative effort in technology transfer during 1975 was an agreement between NASA and the Environmental Protection Agency to undertake a joint program of environmental monitoring, using remote sensing from satellite and aircraft, and the development of remote air-pollution monitoring devices. This agreement authorized a cooperative project in overhead monitoring of surface mining operations in the Western United States, where the impact of energy-resource development will be substantial. The two agencies will also work together to develop a ground-based laser instrument for monitoring air pollution.

In June 1975, NASA sponsored a comprehensive Earth Resources Survey Symposium on potential applications of remote-sensing technology for management of global resources. This gathering attracted 1500 people to Houston, Texas, for four days of discussion on uses of satellite and aircraft data. The symposium was "user oriented" with a high proportion of the attendees from state government, industry, Federal agencies, and other organizations with resource-management responsibilities.

The problems faced by state governments in meeting Federal regulations for resource management prompted NASA to initiate visits to states for workshops on the potential of remote sensing. Maine and New York were visited in the spring of 1975 and a similar meeting with Massachusetts officials was held later in the year. These discussions have increased interest in remote sensing on the part of the states.

Cost/Benefit Studies. NASA conducts economic analysis of the comparative costs and benefits of proposed satellite systems. Approval for new projects is based on reasonable demonstration that economic benefits to the nation would more than offset the cost of development. In 1975 studies were made of prospective U.S. benefits of improved world-wide wheat crop information from an operational Landsat system and additional studies were made of the Seasat project.

Technology Applications

The Technology Applications program has included development of large-scale systems for Federal, state, and local agencies, such as the Activated Carbon Waste-water Treatment System (ACTS). Construction continued in Orange County, California, under a $3.5 million EPA grant on a 500-cubic-meter-per-day municipal pilot plant. ACTS converts sludge into activated carbon by pyrolysis, an energy-conservative, low-air-contamination method. The carbon is then used to treat the water. Another system under test in Mississippi used water hyacinths in the second stage of lagoons to absorb and metabolize pollutants. Other activities included research and development on water monitoring systems and an unmanned vehicle to explore and monitor the deep-ocean bed.

NASA Energy Program

In 1975, NASA's energy programs were funded for the most part by reimbursement from the Energy Research and Development Administration (ERDA) and other agencies having direct responsibilities in the energy field. In June 1975 ERDA and NASA signed a Memorandum of Understanding that provides the framework for use of NASA's laboratories and personnel for supporting the national program of energy research and development. NASA supported ERDA in a number of programs primarily in the areas of wind energy, low-cost solar cells, and solar heating and cooling. As a part of the ERDA Wind Energy Conversion Systems program, NASA designed and constructed an experimental 100-kilowatt wind turbo-generator at the Plum Brook Station in Sandusky, Ohio, to gain experience that might contribute to commercial applications.

Work on low-cost solar cells emphasized improvements in automated manufacturing and testing processes and techniques to reduce the cost of solar cells to levels where they will be commercially attractive. The objective is to achieve a system development market price of $500 per peak kilowatt by 1985.

Research in solar heating and cooling proceeded in two directions. At Marshall Space Flight Center a development program supported ERDA and the Department of Housing and Urban Development in the commercial demonstrations called for by the 1974 Solar Heating and Cooling Demonstration Act. The objective is to develop more cost-effective solar heating and cooling systems together with the instrumentation and data processing systems needed in the test and demonstration programs. The other approach, at Lewis Research Center, sought improvements in component technology for the next generation of solar heating and cooling equipment, and establishment of low-cost manufacturing technologies.

Many advanced concepts have been proposed in energy conversion to improve the efficiency of central electrical generating plants. NASA continued for the National Science Foundation and ERDA, a comparative evaluation of those concepts that employ coal, or coal-derived, fuels. The final report is due in 1976.

In addition, NASA also had a number of programs intended to identify and evaluate the applicability of NASA's space and aeronautics capabilities to energy problems. These programs included: identifying and clarifying the technical problems associated with satellite power systems; assessing the technical and social impacts of disposing of hazardous waste in space; and identifying how aeronautics and space technologies can aid and improve the efficiency of coal combustion as well as of automobiles and aircraft.

Space Flight

Apollo-Soyuz Test Project

The Apollo-Soyuz Test Project (ASTP) mission was planned to accomplish spacecraft rendezvous, docking, undocking, crew transfer, interaction of control centers, and interaction of spacecraft crews. The mission concluded successfully when the U.S. spacecraft splashed down at 5:18 pm EDT, July 24, 1975, approximately 520 kilometers west of Honolulu. All primary mission objectives were met.

Apollo flight crew members were Apollo Commander Thomas P. Stafford, Command Module Pilot Vance D. Brand, and Docking Module Pilot Donald K. Slayton. Soyuz flight crew members were Soyuz Commander Alexey A. Leonov and Flight Engineer Valeriy N. Kubasov.

The Soyuz spacecraft was launched from the Baikonur Cosmodrome at 8:20 am EDT on July 15, 1975. The Apollo spacecraft was launched from Launch Complex 39B, Kennedy Space Center, Florida, on July 15 at 3:50 pm EDT. Soyuz and Apollo contact and docking occurred on time on July 17.

Four crew transfers were made between the spacecraft, with joint occupancy of the two spacecraft for approximately 19 hours and 24 minutes. Additional major crew activity included joint experiments, TV tours of each spacecraft, a joint press conference and activities symbolic of this first international manned space flight.

The Apollo spacecraft was undocked from the Soyuz spacecraft at 8:02 am EDT, July 19. The second docking of the two spacecraft was then accomplished with the Soyuz docking system active.

The Soyuz descent vehicle landed safely within 11 kilometers of the target point at Kazakhstan, northeast of Baikonur, on July 21. The Soyuz crew members were subsequently found to be in good health.

For the four days following undocking (July 19-23), the U.S. crew performed various scientific experiments. Following Apollo splashdown on July 24, the crew and command module were transferred to the prime recovery ship U.S.S. *New Orleans* by crane. It soon became evident from interviews and medical examinations that the crew members were experiencing eye and lung discomfort. Subsequently it was learned that Reaction Control System combustion products, including a small amount of nitrogen tetroxide, had been ingested through the cabin pressure relief valves. Because of the exposure of the crew to nitrogen tetroxide, the crew was transferred to Tripler General Hospital for further observation. Although their general health was good, the crew remained in Hawaii until August 8 to avoid the possibility of bronchial infection from exposure to other people.

Actions to close out this very successful program are nearly complete. A team of Soviet technicians travelled to Houston in November to prepare final technical reports jointly with their American counterparts. Analysis of the results from the experiments conducted by the crews of ASTP as a secondary objective of the mission continued. Of the 28 experiments, 21 were U.S., 5 were joint U.S.-U.S.S.R., and 2 were West German. As of December 1975 preliminary results showed several interesting discoveries. In the field of astronomy, the soft X-ray experiment discovered the first known pulsar outside our galaxy. Located in the Small Magellanic Cloud, it is the most luminous pulsar known by at least a factor of 10. The Extreme Ultraviolet (EUV) Survey experiment confirmed detection of four EUV stars, two of them very strong sources of radiation. While they had been known before by their visible radiation, their extremely high temperatures (some 100,000 kelvins) had not been known.

In the Earth's atmosphere, the Stratospheric Aerosol Measurements successfully measured the layering of aerosols. The data reported 2.5 to 3 times the concentrations of aerosol in the Northern Hemisphere over those in the Southern Hemisphere and that the concentration centered at an altitude of approximately 19 kilometers in the Northern Hemisphere.

Earth observation experiments identified a large northward extension of the Red Sea rift system. The photographs suggested that the primary motion of the Arabian subplate is counterclockwise rotation about the branch point of the fault lines. This is the first observation from space of rotational plate movement.

Space Flight Transportation

Space flight activities provide the transportation and related capabilities necessary to conduct both manned and unmanned operations in space. These activities include the Space Shuttle program for the development of a reusable manned Earth-to-orbit space vehicle; U.S. participation with the European Space Agency (ESA) in a cooperative program for the European-funded development of a Spacelab to be used in the shuttle; development and supporting activities for other elements of the space transportation system; development of new component and subsystem technology; integration planning of future orbital payloads; conceptual studies and research on future space operations; and launch operations and support for expendable launch vehicles for automated space missions.

Space Shuttle

The Space Shuttle is the key element of a Space Transportation System (STS) which will provide round-trip access to space beginning in the 1980s. The Space Shuttle is a reusable space vehicle which will operate between the surface of the Earth and Earth orbit. It will offer unique capabilities to carry out space missions—to retrieve payloads from orbit for reuse, to service or refurbish satellites in space, and to transport to orbit, operate, and return space laboratories. These capabilities can result in savings in the cost of space operations compared to the use of present day expendable space vehicles.

Space Shuttle development is well along. During 1975, major milestones toward development and completion of major subsystems of the orbiter were met as scheduled. The prime contractor selected to build the orbiter vehicle and to integrate the shuttle systems is Rockwell International/Space Division.

The Rocketdyne Division of the Rockwell Corporation has been selected to construct liquid-fueled rocket engines of advanced high-pressure design, which will provide propulsion for the Space Shuttle orbiter. Major hardware components of the main engine, such as the thrust chamber, have been fabricated and tests are presently underway in Santa Susanna, California and the National Space Technology Laboratories in Mississippi.

The external tank which will contain the cryogenic propellants—liquid hydrogen and liquid oxygen—for the orbiter main engines will be designed and built by the Martin Marietta Corporation, Denver Division. They will be manufactured in the government-owned Michoud Assembly Facility near New Orleans, Louisiana.

The fourth element of the Space Shuttle System will consist of two reusable solid rocket boosters, which will burn in parallel with the orbiter main propulsion system to provide additional thrust during launch. The Thiokol Corporation in Wasatch, Utah, has been awarded the contract to build these solid rocket motors.

Rollout of the orbiter is currently scheduled for September of 1976. The first approach and landing test will occur in 1977 at the Flight Research Center at Edwards, California. The orbiter will be unpowered and released from a 747 carrier aircraft. Developmental manned orbital flights will start in mid-1979 aimed at an operational capability by mid-1980.

Spacelab

The Spacelab Program is a joint venture between NASA and the European Space Agency (ESA). The research and development portion is being paid for by the European nations and the Spacelab will be supplied to NASA for flights in the Space Shuttle cargo bay. When it becomes operational in the 1980s, the Spacelab will be a unique facility in which experiments can be performed in an environmentally controlled manned module, or remotely controlled instruments can be mounted on pallets exposed directly to the space environment. The development of a large community of international users is in progress.

In 1975 substantial progress was made in many areas. A NASA/ESA agreement was reached on the basic technical and schedule requirements, and European contractors were well into Spacelab design and began to fabricate the development hardware in July and the first engineering model in December. In addition, in accordance with the Memorandum of Understanding between NASA and ESA, NASA confirmed its intent to procure supplementary Spacelab hardware which will enable the Space Shuttle to carry out an operational role.

Interim Upper Stage

NASA and DOD continued to work closely together this past year. DOD has the responsibility for the definition and development of the Interim Upper Stage (IUS), and NASA is the overall Space Transportation System program coordinator and will be an IUS user. NASA kept track of the DOD progress and the many non-DOD requirements involved in upper-stage missions. A large number of the space payloads expected to be flown by the new Space Transportation System during the 1980s will be put into Earth orbit by the orbiter but then will need an upper stage to propel these payloads to destinations beyond the capability of the orbiter alone. In 1975, DOD and NASA jointly assessed these national mission requirements and evaluated the results from DOD's five study contracts to define IUS. As a result, a multi-staged, solid propellant motor concept was selected for the follow-on IUS Validation Phase, scheduled to begin in mid-1976. A major industry competition for this phase of IUS development is planned by the USAF for early 1976. The initial operational capability for the Interim Upper Stage System is expected in mid-year 1980.

Space Science Payloads

In preparation for the Space Shuttle era, Spacelab science payloads were studied to provide data on new developments for Space Shuttle flights.

In atmosphere and space physics, a feasibility study of an atmospheric, magnetospheric, and plasmas-in-space payload, which included all aspects of the proposed effort from payload configuration to mission profiles, was completed and in-depth project definition begun. This study emphasized the commonality of instrumentation to conduct investigations of the quiescent and dynamic near-Earth environment in the several disciplines represented.

In astronomy, engineering feasibility studies were completed on a meter-class, cryogenically cooled, infrared telescope; a meter-class high-resolution ultraviolet/optical telescope; a meter-class, solar-physics-class telescope; solar X-ray and extreme ultraviolet facilities; and various high-energy astrophysical instruments. These studies will lay the groundwork for future consideration of scientific instruments that could be developed for the Space Shuttle.

Advanced Studies

The Advanced Studies Program is a planning activity to define future transportation and spacecraft systems requirements and to develop advanced mission concepts, as well as the integrated planning required.

During 1975, a number of studies were conducted of future space transportation systems for potential missions during the late 1980s (e.g., erection large structures in space). Other vehicle studies are under way on orbit-to-orbit transfer.

Mission and Payload Integration

The Mission and Payload Integration program continued its activities to coordinate future use of the Space Transportation System (STS) and to ensure hardware and operational compatibility between payloads and the STS.

In 1975, primary emphasis was placed on formalizing early Shuttle mission plans and developing a procedure by which user charges for STS services can be determined.

Launch Vehicle Programs

When the Space Shuttle is fully operational in the 1980s, it will replace most if not all of the current group of expendable launch vehicles. Until then NASA will continue to build and improve these vehicles. Discussion of reimbursable international satellite launches is provided in the section of the report on international cooperation.

Scout. During 1975, the Scout vehicle successfully launched two satellites into orbit: the Small Astronomy Satellite (SAS-C) and a navigation satellite for the Navy. The Dual Air Density (DAD) Explorer satellite was launched but failed to achieve orbit.

Delta. The Delta vehicle successfully launched 12 satellites into orbit, including missions such as the second Landsat Earth resources technology satellite; OSO 8, the last NASA orbiting solar observatory; Goes-A, the first operational synchronous meteorological satellite for NOAA; and the first of a series of three domestic communications satellites for the Radio Corporation of America (RCA) using a new, more powerful Delta (Model 3914) developed by McDonnell Douglas Corporation and financed jointly by them and RCA.

Atlas-Centaur. A failure occurred in the first-stage Atlas booster electrical disconnect plug during the 1975 launch attempt of an Intelsat IV communications satellite. A modification was incorporated, and the vehicle was used successfully in two subsequent launches of Intelsat IV and IVA communications satellites launched for the Comsat Corporation.

Titan IIIE-Centaur. This vehicle was used in 1975 to launch the two Viking spacecraft to Mars. Four launches have been conducted using this vehicle, and launches are planned in subsequent years for payloads beyond the lifting capability of the Atlas-Centaur.

Tracking and Data Acquisition

The objectives of the Tracking and Data Acquisition Program are to provide responsive and efficient tracking, data acquisition, communications, and related support to meet the requirements of all NASA flight projects. Such support is essential for achieving the scientific objectives of all flight missions, for executing the critical decisions that must be made to ensure the success of these flight missions, and, in the case of manned missions, to ensure the safety of the astronauts. During the past year the Tracking and Data Acquisition Program met the requirements of all flight projects on schedule and with excellent reliability.

The majority of the support rendered the flight projects is provided through the facilities of two worldwide tracking networks—the Spaceflight Tracking and Data Network (STDN) and the Deep Space Network (DSN). The STDN furnishes support to all Earth-orbiting missions; the DSN supports the other major class of NASA's flight programs, the planetary and interplanetary missions. All facilities are interconnected by a communications network capable of instantaneous transmission of data and critical commands between spacecraft and the control centers in the United States from which the flights are directed.

Spaceflight Tracking and Data Network

The operational activities of the Spaceflight Tracking and Data Network (STDN) remained at a high level during 1975, supporting an average of 40 individual flight projects. A highlight in 1975 was support of the first international joint manned space flight between the United States and the Union of Soviet Socialist Republics.

Manned Space Flight. The Apollo-Soyuz Test Project (ASTP) mission, during July, was unusual and innovative in international cooperation in tracking and communications support. The U.S. and U.S.S.R. tracking and communications facilities were in constant contact with the Apollo and the Soyuz vehicles and astronauts throughout the critical phases of the mission in the predocking and linkup activities. The U.S. and U.S.S.R. mission control centers were interconnected so that either could communicate with either or both spacecraft. Orbital television coverage of the two spacecraft, for both engineering use and public consumption, was provided by the network stations and ATS-6 satellite.

Laser Tracking Network. In 1975 OTDA established an initial laser tracking network in support of the Geos 3 mission launched in April. The prime objective of the mission is to measure the geometry of the ocean surface. The Geos 3 spacecraft carries a radar altimeter that continuously measures the distance to the surface. To achieve the required accuracy for this instrument, it is necessary to calibrate the altimeter through precise ground tracking. Lasers are located at four sites along the Atlantic coast—Wallops Flight Center, Bermuda, Grand Turk Island, and the Eastern Test Range in Florida. The satellite is tracked by these systems and its altitude is computed from these tracking data. Altimeter data are now contributing to our improved knowledge of sea-surface topography.

Landsat 2. In January 1975, Landsat 2 was launched and the STDN began support two high-data-rate satellites. (Landsat 1 had been launched in 1972 and is still operating.) Special wideband equipment for handling higher data rates has been installed in the stations at Alaska, Goldstone, and in the Network Test and Training Facility at GSFC in Maryland. Under ground station control, Landsat 2 was placed in a Sun-synchronous orbit and so located as to traverse the Landsat 1 ground trace nine days later. (Landsat 1 itself exhibited an 18-day repeat cycle.) Reducing this period is especially important for investigating phenomena that exhibit rapid change. Data from Landsat 1 and 2 are flowing regularly to the Large Area Crop Investigation Experiment (LACIE) users and many other national and international experimenters.

Deep Space Network

The Deep Space Network (DSN) continued to provide excellent support to NASA's planetary and interplanetary missions. The rate of activity remained high.

Mariner/Venus/Mercury. The Mariner 10 spacecraft flew by the planet Mercury for the third time on March 16, 1975, in the final phase of its mission. The flyby occurred at a critical time because the DSN was supporting the closest approach of Helios 1 to the Sun (perihelion), as well as the Pioneer 10 and 11 superior conjunctions—an unusual convergence of critical events. Network pre-launch testing and training activities were also underway for the Viking mission. Commands were sent from the Canberra, Australia, station to Mariner 10 to guide it on its final course within 327 kilometers of Mercury and to transmit back to Earth pictures of the planet's surface.

Pioneer. Following the very successful flyby of the planet Jupiter by Pioneer 11, the DSN assisted in retargeting the spacecraft for its encounter with the planet Saturn in late 1979. Continued cruise support of this new mission objective, in addition to support of the outward-bound Pioneer 10 spacecraft as it heads to the outer edges of the solar system, is providing unprecedented scientific information about the interplanetary space medium.

Viking. The two Viking spacecraft launched in August and September 1975 will travel some 700 million kilometers through space, arriving at Mars when that planet is about 330 million kilometers from Earth. When the orbiter and lander separate, DSN support efforts will become more intense in commanding and controlling the two systems from Earth. The network stations will communicate with the lander and acquire scientific data either directly or through the orbiter. Transmission time is 20 minutes one way from Earth to Mars, which means that many activities, especially during the landing, will have to be controlled by onboard computers.

Tracking and Data Relay Satellite System

A major objective in the longer range plan for the Tracking and Data Acquisition Program is the introduction of Tracking and Data Relay Satellite System (TDRSS) services into the Spaceflight Tracking and Data Network. It is planned that these services will be obtained on a long-term contract with industry, under which the contractor would develop and build the system (both space segment and ground terminal) and operate it to provide the required services to NASA. In July 1975, NASA let two Phase 1 contracts for detailed system design and firm, fixed-price cost proposals for the TDRSS services. From the review of these Phase 1 contracts, a final contractor will be selected in 1976 to implement the system and provide the service in early 1980. Before entering into the final contract, NASA will review the TDRSS program with the cognizant congressional committees.

International Affairs

U.S.-U.S.S.R. Cooperation

Apollo-Soyuz Test Project (ASTP). In July, the joint U.S. and U.S.S.R. ASTP mission flew successfully and on schedule. This mission was provided for in the May 24, 1972, Agreement Concerning Cooperation in Space between the two countries. The mission achieved its technical objective: verification of (1) compatible mechanisms and techniques for rendezvous, docking, and crew transfer; and (2) the required interaction between the ground control centers of each country. ASTP broadened personal contacts between the U.S.S.R. and the U.S., and opened the possibility for future cooperative endeavors in space.

Space Science and Applications. Although ASTP was the major product of U.S./U.S.S.R. cooperation during 1975, cooperative work in space science and applications went forward, as provided in the NASA/Soviet Academy Agreement of January 1971 and endorsed at the May 1972 Summit.

The Soviets provided negatives and prints of the first panoramic photographs of the surface of Venus, taken by the descent modules from Veneras 9 and 10, and imagery obtained by their Mars 4 and 5 orbiters for enhancement by U.S. methods. They also provided supplementary soil samples from Luna 20 as part of a continuing exchange of lunar samples. Coordinated magnetometer observations by the ATS-6 satellite and Soviet ground stations began in October, and in November four U.S. biological experiments were flown aboard the Soviet Cosmos 782 spacecraft. English and Russian versions of a joint work on *Fundamentals of Space Biology and Medicine* were published in 1975.

Preparations began for several joint projects in meteorology: (1) rocketsonde intercomparison tests, (2) sounding rocket study of diurnal variations in geomagnetic conditions, (3) compilation of upper-air atlases, (4) development of common and improved methods of processing satellite temperature-sounder data, and (5) joint research on microwave observations of sea surface and temperature. In the study of the natural environment, NASA and the Soviet Academy embarked on the first phase of a program of remote sensing of vegetation (including crops) at analogous U.S. and U.S.S.R. test sites. Exchanges of ground truth as well as of multispectral data from aircraft and spacecraft are contemplated.

Spacelab Progress

Development in Europe of Spacelab, undertaken in 1973 by the European Space Research Organization (now European Space Agency—ESA) under an agreement with NASA, proceeded on schedule during 1975. Delivery of the first Spacelab flight unit by ESA to NASA is planned for mid-1979. Spacelab will provide the user community with a ground-type laboratory for 7- to 30-day trips into space on board the Shuttle orbiter. It represents a contribution to the Shuttle-based Space Transportation System by the ten participating European countries.

Planning for Spacelab use received increasing emphasis in 1975. NASA and ESA in June completed a six-day series of aircraft flights, using the NASA CV-990 aircraft from Ames Research Center, to simulate a Spacelab science mission of the 1980s. The NASA-ESA Joint User Requirements Group, representing potential Spacelab users in a variety of disciplines, continued to meet to ensure that user requirements were provided to the Spacelab program. In June, the NASA Administrator and the ESA Director General accepted recommendations of a Joint Planning Group on experimental objectives of the first (joint) Spacelab flight. A Joint Program Integration Committee has been established to coordinate planning for that first mission. Working groups, including scientists from the U.S. Europe, Canada, and Japan, met throughout the year to define potential Spacelab missions in the areas of atmospheric, magnetospheric and plasmas-in-space (AMPS) studies, solar physics, and ultraviolet astronomy.

Remote Manipulator

After five years of discussion, Canada, like the European Space Agency became a major international contributor to the development of the Space Shuttle/Spacelab System. Under an agreement between NASA and the National Research Council of Canada (NRCC) signed in July 1975, Canada will develop a Remote Manipulator System (RMS) as an integral part of the Shuttle. The RMS will be operated by astronauts from within the Space Shuttle orbiter to deploy and retrieve payloads in space and perform payload servicing operations. Under the arrangement with NRCC, like that for the European Spacelab development, NRCC will deliver the RMS first flight unit free of cost to NASA and NASA will procure follow-on units as needed. The first flight unit is expected to be delivered in 1979 for test flights of the Shuttle.

Earth Resources

The January launching of Landsat 2 permitted investigators from 45 countries and five international organizations to continue testing and demonstrating the potential utility of NASA-supplied satellite data in a variety of disciplines.

During a NASA-sponsored Earth Resources Survey Symposium held in June in Houston, foreign investigators reported significant results of their studies of data obtained from Landsat 1 and the Earth Resources Experiment Package (EREP) flown on Skylab.

During 1975, agreements were concluded with three foreign nations—Iran, Zaire, and Chile—for their establishment and operation of ground facilities for direct reception of Landsat data. Such stations are already operating in Canada, Brazil, and Italy, and several other countries are planning similar facilities.

New Cooperative Satellite Projects

NASA and the European Space Agency (ESA) concluded an agreement in March for joint conduct of the International Sun-Earth Explorer Project. ISEE will use three coordinated spacecraft (2 NASA and 1 ESA) to advance knowledge of the magnetosphere, interplanetary space, and interactions between them. All three spacecraft will be launched by NASA from the Eastern Test Range in 1977 and 1978.

The French national space agency, CNES, is undertaking the design, development, and operation of the Satellite Data Collection System (SDCS) to be flown on the Tiros-N series of advanced polar-orbiting meteorological satellites, the first of which is to be launched in 1978. Another international contribution to the Tiros-N family of weather satellites is the stratospheric sounding unit provided by the British Meteorological Office. Also party to both these arrangements is the National Oceanic and Atmospheric Administration, which is responsible for managing the operational satellite system following demonstration of the prototype NASA spacecraft.

Reimbursable International Launches

The following cost-reimbursable launches of Thor-Delta vehicles took place in 1975:

- Telesat-C, the third Canadian domestic communications satellite, fom the Eastern Test Range (ETR), May 7.
- COS-B, an ESA scientific satellite to study extra-terrestrial gamma radiation, from the Western Test Range (WTR), August 9.
- Symphonie-B, a second French/German experimental communications satellite, from ETR, August 27.

A new agreement for reimbursable launching was concluded in May with Indonesia for the launch in 1976 of a domestic communications satellite, and similar agreements were concluded in June with Japan for launch of a geostationary meteorological satellite and an experimental domestic communications satellite in 1977, and an experimental broadcast satellite in 1978. Launch services contracts were concluded in March with ESA for launch of Geos, a geostationary magnetospheric research satellite, in 1976, and Meteosat, a geostationary meteorological satellite, in 1977. A similar launch services contract was concluded in March with Italy for launch of Sirio, an experimental communications satellite, in late 1976.

Broadcast Satellite Experiment

On August 1, 1975, the Indian Space Research Organization and NASA inaugurated the one-year cooperative Satellite Instructional Television Experiment (SITE) using the NASA ATS-6 satellite. ATS-6, which operated over the U.S. for a year following launch in May 1974, was moved to a position over East Africa within view of India to provide four hours per day of broadcast time. Instructional television programs, produced by India, are broadcast from stations in Ahmedabad and New Delhi via ATS-6 to some 5000 Indian villages. Some 2400 of these receive the signal directly from the spacecraft on standard TV receivers augmented by a 3-meter antenna and associated equipment to convert the satellite signal into a TV picture. The remaining villages are receiving the signals via terrestrial rebroadcast stations. India is responsible for all ground equipment. SITE is the first large-scale experiment in satellite broadcasting to community receivers in a developing country.

Overseas Tracking Facilities

During 1975, NASA tracking stations in Johannesburg, South Africa; Newfoundland, Canada; Madagascar; and the Canary Islands were closed as planned as a result of changed programmatic requirements. A new five-year tracking station agreement was effected in Ecuador by an exchange of notes in September. NASA has initiated procurement action which will lead to tracking and data relay satellite services beginning in 1980. Such services will permit the closure of additional tracking stations in 1980 and succeeding years.

University Affairs

NASA continues to seek the participation of universities in its programs, especially in those that entail basic, long-term research applicable to NASA objectives. Equally important, in FY 1975 the agency invited members of the university scientific community to participate in planning programs and in ongoing flight experiments that included space applications, life sciences, deep space probes, and lunar and planetary exploration and research. More than 80 percent of the experiments offered in response to the life sciences invitations came from universities and non-profit institutions. University researchers also participated in studies that bear on the effects of the space program on national goals and elements of public concern in environmental, social, and energy problems. NASA has continued to try to increase the participation of schools with predominantly minority enrollment.

In FY 1975, NASA funded 2009 research grants and contracts totaling $112.4 million in support of research and space flight experiments at 282 universities.

Space and Nuclear Research and Technology

The NASA Space and Nuclear Research and Technology programs are directed at providing a technology base for support of current and future space activities by advancing the technology used in systems that transport, power, control, and communicate with the spacecraft, and in scientific instruments needed in current and future NASA space missions. Some of the resulting technology has applications to terrestrial uses as well.

Space Propulsion Technology

NASA propulsion technology encompasses efforts in liquid and solid fuel chemical systems as well as electric powered thrusters. The technology is aimed at expanding mission capabilities and reducing costs.

Liquid Propulsion Technology. The fabrication of the turbomachinery and the regeneratively cooled thrust chamber for a reusable oxygen-hydrogen engine was completed in 1975. Flight-qualified oxidizer valves were redesigned and 1000-hour fracture mechanics tests of titanium in liquid fluorine were completed as part of a technology effort aimed at using liquid fluorine as an oxidizer. Results of research directed at stabilizing atomic hydrogen indicated that at temperatures below 0.3 kelvins, atomic hydrogen may behave ferromagnetically, which could reduce magnetic field strength necessary for long-term storage.

Solid Propulsion Technology. A new start-stop solid rocket capability was demonstrated in which a motor was quenched, reignited, and quenched again. Also, an advanced-technology light-weight composite motor case was successfully fabricated and tested.

Electric Propulsion Technology. A 15,000-hour endurance test of an 8-centimeter, one-millipound (150-watt) ion thruster for station keeping was completed. A 10,000-hour test was also completed on a 30-centimeter, 30-millipound (2.75-thousand watt) ion thruster for primary electric propulsion systems.

Space Energy Systems Technology

Space energy systems technology encompasses the generation, storage, conversion, transmission, and management of the energy required to power spacecraft systems. The technology is aimed at expanding mission capabilities and reducing the weight and cost of energy systems.

Research efforts on nuclear multi-hundred-kilowatt power systems applicable to future missions were focused on thermionic power conversion research. Tests of selected converter electrode materials and configurations were conducted in 1975 to determine their performance characteristics. A handbook was published with detailed information to aid in the design of low cost, standardized solar cell arrays. Virtually non-gassing, sealed nickel-cadmium battery cells, which should exhibit higher reliability and longer life than previous types, successfully completed evaluation tests. An efficient 2000–10,000-watt Brayton turbine power system completed more than 20,000 hours of testing. A 99-percent-efficient solid-state, remote power controller has been developed and tested in 1975. Previous units had efficiencies of 85 percent.

Guidance, Control, and Information Technology

Important technology advances have come from efforts in 1975 to expand NASA's ability to gather, process, transmit, and analyze data in a reliable, efficient, cost-effective manner.

Navigation, Guidance, and Control. A breadboard model of the STELLAR all-solid-state star-tracker for space use demonstrated its ability to automatically track multiple stars in a single field of view. The solid-state approach offers potential for increased reliability.

Sensors. An airborne laser bathymeter has been developed for measuring and mapping the depths of shallow coastal waters down to 50 meters. Compared to the shipborne sonar technique, the system reduces the time of mapping by a factor of 20 and is capable of covering hazardous areas that are inaccessible even to small craft.

Information Systems. A CO_2 laser data transfer system for space-to-space and space-to-ground applications, with data rates 10 times greater than today's systems, was demonstrated in the laboratory.

Materials and Structures Technology

Materials and structures are the building blocks of launch vehicles, spacecraft, and payloads. The technology effort has as its goal the expansion of mission capabilities through the development of new materials and the reduction of structural weight and cost.

Significant advances have recently been made in thermal protection for manned reentry vehicles. Light-weight, rigid silica insulations were developed that have superior high-temperature stability. One of these materials is currently being evaluated by a major automobile manufacturer as an insulation in a potential turbine engine. Progress made in technology for pressure vessels using composite materials overwrapped on metal liners has led to its selection for the design of numerous Space Shuttle pressure vessels with weight savings on the order of 25 percent.

Aeronautics Research and Technology

The NASA Aeronautics Research and Technology programs are directed at developing technology to (1) improve the energy efficiency of aircraft, (2) reduce the undesirable environmental effects of aircraft such as noise and pollution, (3) improve aviation safety and terminal area operations, (4) advance long-haul and short-haul aircraft systems, and (5) provide technical support to the military in maintaining the superiority of military aircraft.

Improving the Energy Efficiency of Aircraft

NASA completed a major study activity during this past year to focus and expand its efforts on technology developments directed at significant improvements in the energy efficiency of future civil air transports. Six major activities were identified that could lead to new aircraft using 50 percent less fuel than the best aircraft flying today.

Potential improvements in many components used in current engines could improve the fuel efficiency of new production versions of current engines by as much as five percent. Results of system design studies completed in the past year indicate that advanced turbofan engines and engines incorporating unconventional engine cycles could be made 10 percent more efficient than engines currently in use on wide-body transports. Recent preliminary calculations indicate that turboprop propulsion systems could be designed to operate efficiently at cruise speeds and altitudes comparable to today's turbofan-powered aircraft with potential fuel savings of 15 to 20 percent. Applications of supercritical aerodynamics and active controls technology to increasing aircraft efficiency rather than speed could produce 10 to 15 percent fuel savings. Extensive use of composites in primary structures could gain 10 to 12 percent fuel savings compared with all-metal aircraft. During this year, a contract was awarded to Lockheed Aircraft Corporation to design, fabricate, and evaluate in airline service an L-1011 vertical tail made from graphite-epoxy composite material.

Reducing Undesirable Environmental Effects

Significant progress has been made during 1975 in the demonstration of technology to reduce and assess the undesirable noise and pollution effects of aircraft.

Reducing Noise from Existing Transport Aircraft. Completion of the REFAN program was particularly significant. The demonstration of modified JT8D engines in Boeing 727 acoustically treated nacelles in ground tests concurrent with the flight tests of engines and acoustic nacelles in a modified DC-9 provide the full technical basis for consideration of the REFAN as an option for retrofit of current narrow body commercial aircraft.

Two-Segment Approach. The completion of the in-service evaluation of the two-segment noise abating approach, using Boeing 727 and Douglas DC-8 aircraft, confirmed the noise relief available from the use of this operational procedure in commercial airline service at major airports.

Noise Prediction. The recent award of a major contract to develop an advanced noise-prediction computational procedure will provide NASA, regulatory agencies, and industry with an improved and uniform capability to predict aircraft noise sources and aircraft noise patterns on the ground around airports.

Engine Pollutant Emission Reduction. Completion of the second phase of two three-phase contracts for demonstration of new technology for reduction of exhaust pollutant emission from large jet engines showed that major reductions in emissions of carbon monoxide and unburned hydrocarbons are possible during low-power operation. Nitric oxide emission reduction by factors of two to three were achieved for high-power operation.

Global Air Sampling. The Global Air Sampling Program (GASP) became operational during this year with installation of three of the four planned airborne sampling systems on Boeing 747 aircraft operated by United Airlines, Pan American, and Qantas airlines. Each system continuously monitors emissions and particulates above 20,000 feet along world airways. A report covering the first three months of operation will be published this winter. NOAA regularly receives data for analysis and correlation with meteorological factors.

Improving Safety and Terminal Area Operations

Significant progress was made in developing advanced technology to improve aviation safety and terminal area operations.

Wake Vortex Reduction. Concern for the potential hazard to smaller aircraft from the wakes left by large aircraft recently prompted the FAA to increase certain aircraft separations. Through model and B-747 flight tests, NASA continued to explore the promising vortex minimization technique of varying spanwise lift distribution. Tests of the NASA laser doppler system for detecting and tracking aircraft wakes near the ground were successfully completed for FAA at Kennedy Airport in New York.

Fire Retardant Materials for Aircraft. Typical aircraft lavatory and cargo bay units were tested under controlled conditions to measure rate and extent of fire build-up, and fire containment capability of current designs. These tests yielded data not only of use in designing new detection and extinguishing systems, but also in determining the thermal environment for new improved materials.

Human Error in Aircraft Accidents. As set forth in a Memorandum of Agreement between FAA and NASA, NASA is designing an Aviation Safety Reporting System for implementation by NASA early in 1976. FAA has determined that the effectiveness of their Aviation Safety (no fault) Reporting Program would be greatly enhanced if the gathering, processing, and analysis of the raw information were done by NASA, rather than the FAA. This would further assure the reporter of anonymity, and consequently increase the flow of information, data that would also be useful in NASA human error research.

Improving Terminal Area Operations. Flight research with the NASA Augmentor Wing Jet Short Take-off and Landing (STOL) Research Aircraft was highlighted this year with a series of automatic landings, the first for a powered-lift aircraft.

Advancing Long-Haul and Short-Haul Aircraft Systems

NASA's effort to integrate the results of research in aerodynamics, structures, propulsion, controls, and avionics to define advanced long-haul and short-haul aeronautical systems continued in 1975.

Quiet Propulsive Lift Technology. NASA evaluated industry proposals to modify a C-8 Buffalo into a Quiet Short-Haul Research Aircraft with an upper-surface-blowing propulsive-lift system. The Quiet, Clean Short-Haul Experimental Engine program progressed from design to fabrication of two turbofan propulsion systems suitable for under-the-wing and over-the-wing propulsive-lift installations.

Supersonic Cruise Aircraft Research. NASA YF-12 aircraft were flown at supersonic speeds to evaluate the impact of engine emissions on the stratosphere and to test advanced aircraft structural panels. Tests of models of new aircraft configurations in wind tunnels showed that increased ranges are possible with the major improvements achieved in aerodynamic cruise efficiency. Hypersonic research experiments in propulsion, structures, and aerodynamics were complemented by a joint study with the Air Force to define a hypersonic research aircraft for carrying ground-developed systems into flight to solve critical design problems.

Control Systems. Flight tests with a commuter-type aircraft are exploring the merits of a split-control-surface stability augmentation system as a low-cost means of improving aircraft control and ride quality in a cooperative program with Kansas University and Beech Aircraft Company.

Technical Support to the Military

In addition to the continuing broad-based support of military aircraft development programs, a number of notable accomplishments occurred in 1975. The Highly Maneuverable Aircraft Technology program reached the point of a contract award for the design and fabrication of two remotely piloted research aircraft to be used to exploit high-risk technology opportunities. Two joint NASA/Army Experimental Aircraft Programs—the Tilt Rotor Research Aircraft and the Rotor Systems Research Aircraft—have both progressed to the final assembly phase. Each program will proceed to the ground testing of two aircraft early in 1976.

Disseminating Technology and Benefits

The NASA Technology Utilization Program, now in its thirteenth year, is designed to encourage and promote the secondary application and use of aerospace-developed technology in the industrial and public sector of the nation. Since the program's inception, a spectrum of transfer and dissemination mechanisms have been established and institutionalized by NASA to interact with potential users in the non-aerospace community.

During 1975 the publications program continued to be the mainstay for stimulating user awareness and has been strengthened with a NASA-Small Business Administration agreement to develop cooperative programs to serve the technological needs and interests of small businesses. In addition, NASA has initiated an expansion of its Industrial Applications Center network into other regions of the U.S., particularly in highly industrialized urban areas which were previously difficult to serve.

User agencies at the Federal, state, and local levels have continued to profit by NASA's technology applications efforts to adapt or otherwise reengineer aerospace technology to meet their needs. A wide range of projects, including better brakes, highway profiling, corrosion-free paint for bridges, prosthetic limbs, and biomedical instrumentation devices, have been actively pursued by NASA in conjunction with user agencies. Announcement of a new and improved commercialized Fire Fighters Breathing System was the 1975 highpoint in the technology applications program.

Low Cost Systems. The Low Cost Systems Office was established to lead an agency-wide effort to reduce the overall cost of space systems. The program was structured to develop standardized spacecraft components, ground support equipment, and software designed to satisfy a majority of anticipated mission requirements and to study the cost impact of NASA's business and program practices. To date, a number of components have been declared standard. These include a tape recorder, spacecraft computer, inertial reference unit, initiator, star tracker, battery, transponder, attitude control assembly, and a specification for solar cells. Panels and ad hoc working groups are currently developing assessments of additional standard equipment and specifications in areas such as Sun sensors, Earth sensors, solar panels, additional batteries and battery cells, standard command detectors, standard spacecraft computer compilers, and a standard gimbal and drive for antennas of other spacecraft using the tracking and data relay satellite system. This office has also coordinated agency-wide assessments of Multi-Mission Spacecraft. A System Integration activity has been established as part of the Standard Equipment Program to ensure that compatible interfaces exist between the items of standard equipment currently being developed and procured. Interface management techniques will be established to maintain this compatibility. Current practices which are being studied to reduce costs are testing procedures, specifications, logistics concepts for standard items, assessment between costs and risks; and assessment and simplification of specifications. Future studies are planned on spare-parts concepts and the trade-off between costs and reliability. A Catalog of Available and Standard Hardware has been established, providing computer retrievable information on hardware already declared as standard and an index of other flight-qualified hardware suitable for multimission use. Project Management Workshops have been held with NASA managers to exchange information on cost-effective project management practices.

III Department of Defense

Introduction

The Department of Defense space activities in navigation, communications, meteorology, and space surveillance support both the strategic and tactical forces, and DOD space research and development and the space ground facilities ensure that the technology is available for new space system options in the future. In aeronautics the primary emphasis of the DOD effort is development of improved aircraft systems for replacement and modernization of the operational inventory. The substantial aeronautical research and development program provides the technology for new operational concepts and capabilities with reduced acquisition and support costs.

During 1975, the Joint Program Office of the NAVSTAR Global Positioning System continued to make progress in the development of prototype NAVSTAR satellites and user equipment. When operational, the system will provide unprecedented accuracies of position and velocity in three dimensions. This will greatly enhance military capabilities for enroute navigation and position fixing. Until NAVSTAR becomes available, the Navy Navigation Satellite System (TRANSIT) continues to provide a world-wide two-dimensional position-fixing system in support of the strategic forces. Improved Transit satellites will provide the system with greater survivability and longer mission lifetime.

In world-wide military communications DOD has placed heavy emphasis on satellite communications systems to fulfill its diverse requirements. The Defense Satellite Communications System (DSCS) supports the global requirements of the World-Wide Military Command Control System. The space segment of the DSCS suffered a loss in 1975 when two Phase II satellites failed to achieve the desired orbits. However, through mutual agreement the U.S. will rely on the NATO II-B and the United Kingdom Skynet satellites so that limited operational capability will be maintained through 1977, when the next series of Phase II satellites will be launched.

Authorization to procure the first flight-model spacecraft was granted to the Navy Fleet Satellite Communications System. The installations of Fleet Satellite Broadcast Receivers are on schedule. The Air Force Satellite Communications System, which supports the communication, command, and control requirements of the strategic forces, completed initial operational testing of its terminal in 1975. The Army also successfully tested its transportable ground terminals during the past year.

DOD participation in the Space Shuttle program was increased in 1975 to keep pace with the NASA development program. A solid-propellant concept was chosen for validation and development of the Interim Upper Stage (IUS). The IUS will be used with the Shuttle by both DOD and NASA until the NASA-developed Space Tug is available in the mid-1980s. The Space Shuttle holds great promise for reducing the cost of military space operations while introducing a new capability that would make DOD space operations more effective.

In space research, the Defense Advanced Research Projects Agency is advancing the technology of space surveillance. Concurrently, improved techniques for space-object identification are being investigated.

Significant events and accomplishments in aeronautics took place in 1975. The F-16 was selected as the air combat fighter by the U.S. Air Force. This highly maneuverable fighter will complement the F-15 Air Superiority Fighter, which completed a very successful year of test and evaluation. The Navy selected the F-18 as its air combat fighter to complement its F-14A tactical fighter, which is being deployed successfully into the fleet. The A-10 close air support aircraft completed its development tests with excellent results. The A-10 program is currently in low-rate production.

The first of four Research, Development, Test and Evaluation B-1 aircraft continued its flight-test program during 1975. Accomplishments achieved included supersonic flight and aerial refueling.

Finally, the need to conserve energy resources has had a sizable impact on DOD aeronautical research and development efforts. In 1975 advances in composite materials technology indicated that substantial reductions in aircraft weight can be realized through use of composite structures. Also, in cooperation with NASA, DOD is engaged in long-term configuration development, exploiting advances in aerodynamic design along with advanced propulsion and composite materials.

Space Activities

Defense Satellite Communications System (DCSC)

The Defense Satellite Communications System's primary mission is the communications support of the National Command Authorities and the World-Wide Military Command and Control System (WWMCCS).

Four of the Phase I satellites launched in 1966-1968 are still working. However, this limited number is unable to provide continuous connection between specific ground stations and are not considered operational.

Two high-powered synchronous-orbit satellites make up the present DSCS II space segment. On May 20, 1975, two additional Phase II satellites were launched aboard a Titan IIIC vehicle. The third stage of the Titan failed to ignite, and both satellites were lost. Since the Atlantic DSCS II satellite was able to accommodate the NATO satellite requirements, NATO authorized the United States to relocate the Atlantic NATO II-B satellite in the Eastern Pacific. Along with limited access to the United Kingdom satellite, this gave the U.S. a limited worldwide system.

In early September 1975, the Atlantic DSCS II satellite experienced problems in antenna-pointing accuracy, so the NATO II-B was moved back to the Atlantic. Although the problems on the Atlantic DSCS II satellite were subsequently corrected, only those circuits not provided through commercial means have been restored. The present space segment of the DSCS provides full coverage in the Western Pacific and Atlantic areas, limited coverage in the Indian Ocean area, and no coverage in the Eastern Pacific area.

The Air Force is on contract for six additional DSCS II satellites. Delivery of these satellites will be accelerated where possible so that the first two satellites of this group can be launched in March 1977. In addition, there is the possibility of using one of the three future NATO III satellites if the need arises.

As for the ground systems, the Army's first two heavy transportable terminals were installed at the Satellite Test Center in Sunnyvale, California. The Navy installed and activated additional shipboard terminals for operation with the DSCS. Initial production units of digital modulation equipment were available for use in the DSCS ground terminals in November 1975.

Fleet Satellite Communications System

The objective of the Fleet Satellite Communications System (FLTSATCOM) is to deploy a satellite communications system to satisfy the most urgent, worldwide, near-term tactical communications of the Navy and Air Force. Authorization was granted in August 1975 to procure the first flight-model spacecraft, with an option for a second to be exercised after completion of a test program in January 1976.

Production approval for additional spacecraft is expected to be granted in 1976. More than 200 Fleet Satellite Broadcast Receivers have been installed aboard ships. Technical and operational evaluations of the Common User Digital Information Exchange Subsystem have been completed. Development continues on other information exchange subsystems providing high-speed data interchange between ship and shore. The first FLTSATCOM launch is projected for late 1977.

Air Force Satellite Communications System

The Air Force Satellite Communications System (AFSATCOM) will provide communications to satisfy high-priority national requirements for command and control of strategic forces. The AFSATCOM space segment included Air Force Ultra High Frequency (UHF) communications capability on the Navy FLTSATCOM spacecraft and the Air Force Satellite Data System spacecraft, with global backup on other DOD satellites. The AFSATCOM terminal segment will consist of airborne, mobile, and fixed terminals. Initial operational testing of the strategic terminal was completed in 1975. Terminal production is to begin in 1976.

Army Satellite Communications Activities

The Army Satellite Communications Ground Environment includes development of strategic and tactical satellite communications ground terminals for use by all services. Two major projects are the DSCS Phase II support effort and the Ground Mobile Forces Satellite Communications Program. A third, smaller project is exploratory development to support the two major projects.

The small terminal contract for test models of militarized, highly transportable ground terminals was awarded in December 1972. Seven models were delivered in June 1975 and are undergoing operational testing. These terminals will provide multichannel communications for the ground mobile forces in the field through the DSCS satellites. Engineering development has begun on a UHF manpack terminal and on a UHF vehicular terminal.

The interim operational capability has been upgraded and continues to support various contingencies and field exercises. Operational testing through the year has assisted further development of concepts for the use of this significant transmission medium in support of combat readiness.

International Cooperation in Space

The United States has assisted in the development, procurement, and launching of communications satellites for both the United Kingdom and NATO. Since both of these systems grew from the U.S. DSCS Phase I system, all three are interoperable. During 1975, significant progress was made at U.S., U.K., and NATO meetings to improve plans for more effective use of SATCOM systems in the event of failures. When one of the DSCS satellites failed in early September 1975, these international arrangements proved to be very worthwhile sources of international cooperation. The U.S. has provided support to the U.K. and NATO via the DSCS satellites, while the U.K. is providing support to the U.S. via their Skynet satellite. NATO has made their NATO II-B satellite available to the U.S. in times of need.

Since 1973 the United States has supported NATO in the development and procurement of satellites for the NATO Phase III SATCOM Program. In 1976 NASA will provide launch services for the first NATO III satellite, while the U.S. Air Force will provide operational services.

Progress has continued toward establishing the Direct Communications Link (DCL) called for in the 1971 agreement between the United States and the U.S.S.R. The DCL is to use satellite communications circuits via both Intelsat and Molniya. In implementing the improved U.S.-U.S.S.R. Direct Communications Link, the Intelsat segment has been undergoing end-to-end testing since December 1974, and the Soviet Molniya link has been partially tested.

Navigation Satellite Activities

The U.S. Navy Navigation Satellite System (TRANSIT) is beginning its second decade of operation. TRANSIT provides a world-wide, two-dimensional system for position fixing at least every two hours to an accuracy of less than 200 meters. TRANSIT has been adapted for other activities, such as offshore oil exploration and the measurement of polar motion. Recently developed satellites will have greater survivability and longer orbital lifetime. These improved satellites are able to compensate for orbital disturbances caused by solar radiation pressure and atmospheric drag. One such satellite was launched for DOD by NASA in October 1975, and another is scheduled for launch in 1976. TRANSIT will be replaced in the future by the more accurate NAVSTAR Global Positioning System.

The NAVSTAR Global Positioning System is a joint service development program which will provide a world-wide, continuous position-fixing capability in three dimensions. When operational, NAVSTAR will consist of 24 satellites in 17,600-kilometer orbits and a ground segment for controlling the satellites. Estimates are that some 25,000 to 35,000 users in almost every kind of military mission will use NAVSTAR for navigation and position fixing. With continuously transmitted satellite signals, a user will be able to determine his position within 10 meters and velocity within 0.03 meters per second in three dimensions.

Development of NAVSTAR is in the concept-validation phase, with the launch of the first satellites scheduled in 1976 and 1977. This phase will lead to a decision in early 1978 regarding full-scale engineering development of NAVSTAR. During 1975, the Joint Program Office has continued to develop the prototype NAVSTAR satellites and the user equipment and to plan for support of the Navy's Improved Accuracy Program. Significant progress was made in the development of user equipment, including manpack, high-performance, and low-cost models. Civil agencies have expressed significant interest in the system.

Defense Meteorological Satellite Program

The Air Force operates the Joint Service Defense Meteorological Satellite Program (DMSP), which provides timely, high-quality visual and infrared weather data to support military operations. Two satellites are maintained in orbit, one providing data in the early morning and evening, and the other near local noon and midnight. The satellites are in polar, Sun-synchronous orbits at an altitude of 720 kilometers and have an orbital period of 102 minutes. Weather data from the entire Earth are stored aboard the satellites and transmitted to Air Force Global Weather Central in Nebraska. In addition, real-time imagery of their local area is transmitted to mobile readout stations around the world to support tactical operations. The DOD is cooperating with NASA in the development of the Tiros-N domestic weather satellite. Tiros-N will be an adaptation of the DMSP vehicle and will be operated by the National Oceanic and Atmospheric Administration (NOAA).

Space Shuttle

DOD's participation in the Space Shuttle has increased this past year to keep pace with the NASA development program. The Air Force has continued its close interface with NASA in various Shuttle design reviews and at planning meetings to ensure that DOD requirements are being incorporated into the evolving design. In early September 1975, the Air Force chose an expendable, solid-propellant concept for validation and development of the Interim Upper Stage (IUS). Choice of a solid-fueled as opposed to a liquid-fueled IUS is expected to provide advantages in unit and life-cycle costs, as well as high overall reliability. The IUS will be used with the Shuttle by both DOD and NASA until the NASA-developed upper stage is available in the mid-1980s. The IUS will be ready for use at Kennedy Space Center when the Shuttle launch complex becomes operational in 1980. DOD payloads that require low-inclination or high-altitude orbits will begin using the Shuttle at that time.

DOD plans West Coast Shuttle launch and landing facilities at Vandenberg AFB, California, with an expected operational date of December 1982. DOD payloads requiring polar or near-polar orbits will begin using the Shuttle at Vandenberg shortly afterwards.

Space Boosters

The Atlas and Titan III standard launch vehicles and the surplus IRBM SM-75 Thor and surplus ICBM Atlas E/F vehicles comprise the DOD family of space boosters. During 1975 there were seven Titan III launches, including one unsuccessful SM-75 Thor launch, one successful Atlas-Agena launch, and one unsuccessful Atlas F launch in 1975.

Space Ground Support

DOD Range, Tracking, and Data Acquisition Facilities

Department of Defense space activities are principally supported by the Air Force's Eastern Test Range, Space and Missile Test Center, Satellite Control Facility, and Arnold Engineering Development Center; the Army's White Sands Missile Range and Kwajalein Missile Range; and the Navy's Pacific Missile Test Center. These facilities also support a wide variety of test and evaluation activities and are available to DOD, other Federal agencies, industry, and international agencies that may require their support.

Eastern Test Range (ETR). During 1975 the Air Force ETR provided launch, tracking, and data acquisition support to a variety of DOD space and ballistic missile operations, NASA space science programs, and commercial communications satellite launches under the overall sponsorship of NASA. Test support was provided also for the SRAM, an Air Force air-launched missile, and the COMPASS COPE drone. The Apollo-Soyuz Test Program, conducted in cooperation with the U.S.S.R., was successfully completed. Modernization and improvement of range instrumentation and associated supporting systems continued, with emphasis on telemetry, radar tracking, range safety, real-time data distribution, and adaptation of selected instrumentation to a mobile configuration. These improvements enhance the ETR capability to meet user requirements, increase the efficiency of instrumentation, and provide flexibility to support the broad variety of test programs. Preliminary planning and assessment of the ETR role in the Space Shuttle Program was initiated in cooperation with NASA and the Air Force Space and Missile System Organization.

Space and Missile Test Center (SAMTEC). SAMTEC manages, operates, and maintains the Western Test Range, a national range, in support of DOD, NASA, and others. SAMTEC provides range tracking, data acquisition, and flight safety support for all ballistic missile and space launches from Vandenberg Air Force Base, California. The number of launches has remained essentially constant at approximately 65 ballistic and space launches per year. SAMTEC has again experienced an increase in aircraft testing, principally in the Offshore Test Area over the Pacific.

SAMTEC has been actively engaged in planning for the first Space Shuttle launch from Vandenberg AFB. Extensive construction will be required for launch, maintenance, and logistic facilities. SAMTEC has continued to improve and modernize the range instrumentation, with emphasis on the range telemetry system.

Satellite Control Facility (SCF). In 1975 the SCF supported a workload of 23 launches, over 51,000 satellite contacts, and nearly 53,000 network support hours. To reduce costs, one of the SCF network's ten worldwide satellite tracking stations, Kodiak Tracking Station, was deactivated. Work is progressing on improvement of communication and data systems. Replacement of the on-line computers at the Satellite Test Center is nearly completed, and several of the new mission control centers have been completed. Development efforts are underway on the support capability for the DOD/NASA Space Transportation System.

Arnold Engineering Development Center (AEDC). AEDC provides environmental simulation testing for major aeronautical, missile, and space programs under development. AEDC has 40 ground environmental test facilities, of which over half are unique because of one or more of the major test parameters they simulate. AEDC supported a wide variety of testing, ranging from basic R&D investigations to scale-model testing. In addition there is full-scale flight hardware testing at AEDC. Major DOD programs supported include F-15, B-1, Advanced Ballistic Reentry Systems, Minuteman, Trident, and Advanced Combat Fighter. AEDC also supported NASA's propulsion, aerodynamics, and Shuttle testing.

White Sands Missile Range (WSMR). The Army's WSMR continued to provide support to DOD and NASA aeronautics and space programs. A full spectrum of launch, flight, and recovery services was provided, including ground and flight safety, surveillance, command and control, and data acquisition and analysis. Army and Air Force programs included sounding rockets and atmospheric-measurement balloons. NASA support included the Skylab calibration rockets, R&D and operational balloons, upper atmosphere rocket soundings using the Aerobee rocket, numerous smaller rockets, and astronomical test programs.

Kwajalein Missile Range (KMR). The Army's Kwajalein Missile Range continued to provide, maintain, and operate a national range to support technological advances in both offensive and defensive strategic weapon test programs. KMR is our only range with the technical capability to obtain critical data associated with terminal ballistics of intercontinental ballistic missiles. KMR radars have also provided back-up tracking data for NASA's space program. By agreement between the U.S. and Japan, a temporary down-range tracking station was established on Kwajalein to support two launches in the Japanese space program.

Pacific Missile Test Center (PMTC). During 1975 the PMTC (formerly Pacific Missile Range) provided support to DOD and NASA in missile, aeronautics, and space activities. PMTC provided support range services for most launches from Vandenberg, including NASA's Landsat 2, Geos 3, Nimbus 6, and COS-B launches. PMTC aircraft provided real-time telemetry reception and data transmission from the ATS-6, ATS-1, and ATS-3 satellites to the NASA Goldstone, California, tracking site for real-time relay through the NASA tracking network.

Space Research and Technology

Space Science

Solar Radiation Monitoring Program. The Navy is conducting research to measure and forecast solar parameters and their effects on electromagnetic systems. A significant part of this program is the SOLRAD-HI project, which places two Sun-oriented satellites in 112,000-kilometer circular orbits. These satellites will measure solar X-rays, ultraviolet radiation, and particle emissions. The spacecraft have been completed and will be launched along with several other satellites on a single Titan III booster in February 1976 as part of the space test program.

Environmental Remote Sensing. The Navy established in 1975 an Environmental Remote Sensing Coordinating and Advisory Committee. This committee is tasked to ensure research and development toward efficient remote sensing* for obtaining all-weather global environmental data.

The scope of Navy activities in calendar year 1975 included the following: (1) application of data from DOD, National Oceanic and Atmospheric Administration (NOAA), and NASA aircraft and space platforms; (2) development and implementation of data acquisition and analysis; and (3) work on prediction and dissemination technology for operational fleet support. Thermal infrared, visual imagery, and sea-surface temperature maps were used to improve the effectiveness of coastal surveys. Visual, thermal infrared, and passive microwave images and maps from DOD, NOAA, and NASA aircraft and satellites were used in support of research experiments, fleet exercises, and logistic operations in the Arctic.

Experiments for the development of sensors for global all-weather measurement of sea-surface roughness, temperature, surface winds, and salinity by radar altimeter and microwave radiometers were carried out, using Geos 3 and Skylab data. Close liaison has been established with NASA and NOAA for cooperative planning of experiments and effective data utilization from future missions of Tiros-N, Nimbus-G, Seasat-A, and Goes satellites.

Gamma Ray Spectrometer Experiment. Fabrication and component testing of a second-generation, high-resolution gamma ray spectrometer and charged particle detector are continuing in preparation for launch in the spring of 1978. These instruments will permit the detection, tracking, and analysis of radioactive debris from nuclear explosions, as well as provide measurements of upper atmospheric contamination by nuclear bursts. This experiment is a follow-on to an instrument package launched in October 1972, which surveyed the radiation background in the upper atmosphere and near space, and which demonstrated that instrumentation could locate radioactive sources and therefore could monitor and measure effects of nuclear explosions on the environment. Improved detectors and state-of-the-art mechanical sensor cooling in the forthcoming experiment will permit long-term monitoring and analysis of upper atmospheric and near-space gamma radiation and will provide data for design of sensors for operational space systems.

Space Surveillance

The purpose of the Space Surveillance Program is to develop and demonstrate new optical techniques that will significantly reduce the cost of systems that search for and automatically detect space objects. Activity includes data gathering on current space objects, using the Maui Optical Station. These data will form a catalog of target signatures needed for detailed systems design. A new generation of sensors with very large formats, employing advanced readout and data processing schemes, is under development. The final phase of this multi-year program will be verification experiments to demonstrate the capabilities of these advanced sensors for autonomous surveillance of space. Ground tests will take place at the Maui Optical Station. The program will provide a base of demonstrated technology for cost-effective improvement of the Space Surveillance and Detection Tracking System (SPADATS).

Space Object Identification. Since 1972 the Defense Advanced Research Projects Agency (DARPA) has been involved in a broad research program to advance the technologies for space-object identification. Both optical and radar techniques are being refined, developed, and demonstrated to measure the physical characteristics of space objects. Transfer of this technology to the services is underway. Millimeter-wave-imaging techniques are approaching the point where demonstration of their potential is possible. A program to develop a wideband laser imaging radar is also underway. In the optical area, sensors are being developed to measure the effects of atmospheric turbulence on pictures of space objects taken by large ground-based telescopes. Removal of the atmospherically imposed distortions will greatly improve the present image quality. A verification test of an atmospheric correction imaging system is planned for the Maui Optical Station. Radar and optical techniques developed under DARPA sponsorship will obtain diagnostic information on our own satellites and serve as a prime source of technology for improvement of the Space Surveillance and Detection Tracking System.

Aeronautical Activities

Aircraft and Aircraft Systems

F-16 Air Combat Fighter Program. During 1975 the F-16 was selected as the air combat fighter for the U.S. Air Force. The Air Force plans to procure 650 aircraft to modernize its tactical fighter force. In June 1975 the European Consortium (Belgium, Denmark, the Netherlands, and Norway) entered into a formal commitment to purchase the F-16 to replace its aging F-104 fighter. The European Consortium will share in the production of the aircraft and plans to purchase 348.

The F-16 air combat fighter is designed to meet the air combat challenges of 1980-1990. Furthermore, it will provide a lower cost fighter to complement the F-15.

F-15 Air Superiority Fighter. The F-15 Air Superiority Fighter Development Program is nearing completion and the Tactical Air Command completed one year of training experience in November 1975. Over 4500 hours have been flown in the vigorous F-15 test program with excellent performance results.

F-18 Carrier-Based Strike Fighter. In 1975 the Navy selected the F-18 as the Navy air combat fighter. This aircraft will replace the remaining Navy and Marine Corps F-4 Phantom fighters. An attack version of the F-18 will replace the aging A-7 light attack aircraft in the mid-1980s. Introduction of this aircraft into the fleet will provide the tactical commander at sea with a high performance, agile strike fighter capable of defeating the projected air threat and surviving over hostile territory. The F-18, though not as sophisticated as the F-14, will complement the F-14 in maintaining maritime air superiority.

F-14A Carrier-Based Tactical Fighter. In early 1975 two F-14A squadrons returned from their first extended deployment to the Western Pacific/Indian Ocean. The F-14A compiled the most successful fleet introduction record of any new Navy aircraft. The two East Coast F-14A squadrons completed deployment on schedule and are on the U.S.S. *John F. Kennedy* in the Mediterranean. Two additional F-14A squadrons are completing transition on schedule and were assigned to the U.S.S. *Constellation* in late 1975. The F-14A has proven to be a highly maneuverable and agile fighter, demonstrating its air superiority capability in impressive fashion.

The F-14A continued to demonstrate its multi-track, multi-shot Phoenix air-to-air missile, completing 21 successful launches with a success rate of 90 percent.

F-4 Wild Weasel Avionics. The objective of the Air Force's Wild Weasel research and development program is to design, fabricate, and flight-test a system that will give strike aircraft the capability to search out and destroy hostile radar systems. This will greatly improve the effectiveness of tactical forces in suppression of air defenses. In 1975, the follow-on R&D and pilot modification programs proceeded on schedule. The Wild Weasel is being designed to be compatible with the next generation of anti-radiation missiles. Plans are underway to modify a significant number of newer F-4s with the Wild Weasel avionics system.

AV-8B VSTOL Light Attack Aircraft. The AV-8B is the advanced version of the Marine Corps AV-8A Harrier. Design refinements and aerodynamic changes will yield significant range/payload improvements over the current operational AV-8A. The AV-8B will replace the Marine Corps AV-8A and A-4M light attack aircraft as they reach the end of their service. It will provide the Marine Corps with a flexibility of basing that is especially suited for optimum support of amphibious operations.

A-10 Close Air Support Aircraft. The A-10 development program entered the low-rate production phase late in 1975 with the delivery of the first production aircraft. All six test and evaluation aircraft were delivered, and development tests required prior to a decision on full-production were completed with excellent results. The test and evaluation aircraft performed well from a maintenance standpoint also. Maintenance manhours per flight hour are very low and the operational readiness criteria are being exceeded by 40 percent. One fuselage frame failed in fatigue testing, but a fix has been identified that should cause minimal impact to the program and have no adverse effect upon performance.

B-1 Bomber Program. The Air Force is developing the B-1 aircraft to modernize the strategic bomber force in order to maintain a credible manned bomber element of the strategic Triad in the 1980s and beyond. The first of four Research, Development, Test, and Evaluation (RDT&E) aircraft began flight test in December 1974. Significant accomplishments during 1975 included the first supersonic flight and aerial refueling.

The second RDT&E aircraft underwent a series of static-proof load tests duplicating the conditions that will be encountered in flight. Having successfully completed these tests, the aircraft was returned to the manufacturing facility for installation of hydraulic and electrical equipment. Its first flight is scheduled for the latter half of 1976.

The third RDT&E aircraft has completed major assembly and is starting its system checkout. It will be the first B-1 aircraft to have a full offensive avionics system. Flight testing is scheduled for the first half of 1976.

Congressional approval has been given for the fourth RDT&E aircraft, which will be used for defensive avionics testing in 1978-1979.

COMPASS COPE Remotely Piloted Vehicle (RPV). The COMPASS COPE is a high-altitude, long-endurance RPV which is being developed to perform communications relay and surveillance tasks. Two different prototype aircraft have been built. Both designs are basically jet-powered sailplanes with a high proportion of gross weight allocated to fuel.

During 1975 extended prototype flight testing took place at Cape Canaveral Air Force Station, Florida, in which hands-off automatic landing of the aircraft was demonstrated. A decision on continued development will be made in 1976.

Heavy Lift Helicopter (HLH). The original HLH program goal was to develop a tandem-rotor, three-engine, crane-type helicopter designed to carry bulk cargo externally, to off-load containerships, and to move heavy tactical equipment. A newly developed fly-by-wire flight control system, slated to be an an advanced technology component for the HLH, was successfully demonstrated in flight, and tests of components of this control system were completed in March 1975. An austere prototype was being built to validate these advances, and first flight of the prototype HLH had been scheduled for April 1976. However, under the direction of Congress, the Army is terminating this program.

Advanced Medium STOL Transport (AMST). The Advanced STOL (Short Takeoff and Landing) Transport program involves two advanced development prototypes (the YC-14 and YC-15) built by competing contractors to demonstrate STOL technology and the operational utility of STOL designs. The YC-15 had its first flight in late August 1975 and is proceeding with a successful flight test program. Final assembly of the YC-14 was begun in July 1975; it is scheduled for its first flight in August 1976.

The AMST is designed to provide improved short-field performance, higher speed, an outsize cargo capability, and greater productivity than is possible with current tactical airlift aircraft.

Utility Tactical Transport Aircraft System (UTTAS). The UTTAS helicopter is designed to transport 11 combat-equipped troops, resupply them while in combat, and perform aeromedical evacuation and repositioning of reserves. Replacing the UH-1H, its increased payload will reduce the number of troop-transport helicopters.

In August 1972, contracts were awarded for the production of three prototypes. Since then, each prototype has flown approximately 400 hours; a decision on the final prototype design is slated to come in 1976.

YCH-53E Helicopter. The YCH-53E helicopter completed its first Navy preliminary evaluation tests in February 1975. The program entered the engineering development phase in April 1975 with authorization to fabricate two pre-production prototypes and a static-test article. Tests on recent modifications (a new horizontal stabilizer, new set of improved rotor blades, and changes to the automatic flight control system) continue in preparation for the second Navy Preliminary Evaluation scheduled for the end of 1975. When operational, the YCH-53E will significantly upgrade the amphibious forces' heavy-lift capability.

Advanced Attack Helicopter (AAH). The AAH is a two-phase development program. The first phase is aimed at obtaining the best airframe and will culminate in a fly-off between two competing designs. The full mission equipment will be developed and integrated in the second phase. Significant milestones were achieved during 1975. Both prototypes completed 50 hours of ground pre-acceptance tests. First flights occurred for both prototypes in late 1975. Phase I is scheduled for completion in November 1976.

Cobra/TOW Helicopter. The Army Cobra/TOW program includes retrofit of the TOW antitank missile system in 290 existing Cobra helicopters and purchase of new aircraft equipped with TOW (*T*ube *L*aunched *O*ptically Track *W*ire Guided) missiles. Deliveries of retrofitted Cobra/TOW helicopters began in June 1975. Tests of the uprated engine, transmission, and dynamic components for Improve Cobra Agility and Maneuverability (ICAM) and flight tests of two prototypes with ICAM components were successfully completed in 1975. These ICAM components will be incorporated in new AH-1S and the 290 retrofitted AH-1S Cobra/TOW helicopters. In addition, a Marine Corps program provides for new procurement of the twin-engine Seacobra AH-1J with modifications to include the TOW missile system. Qualification tests of the uprated engines for the Seacobra were completed in early 1975.

E-3A Airborne Warning and Control System (AWACS). The E-3A provides all-altitude air, sea, and ground surveillance with command, control, and communication functions. It can be deployed worldwide with strike forces to meet the requirement for survivable air defense surveillance and control. It can also be deployed rapidly to provide for a tactical command/control capability.

In February 1975, the Secretary of Defense certified the effectiveness of the E-3A. This certification was founded on the results of the extensive system integration demonstration in 1974, on the report by a group of independent technical experts on radar and electromagnetic-countermeasures, and on exhaustive DOD analyses. Congressional hearings on the certification were held in March 1975, and production funds for six E-3As in Fiscal Year 1975 were approved. First delivery of an operational aircraft is scheduled for November 1976. Fabrication of the three pre-production development test and evaluation prototypes has continued, and flight tests began in 1975.

The first step toward a NATO acquisition program for an Airborne Early Warning (AEW) system, based on the E-3A, took place in April–May 1975. An embryonic NATO AEW Program Office was established and began a contract definition study for an AEW system. The NATO Defense Ministers will consider procurement in June 1976.

E-4A/B Advanced Airborne Command Post (AABNCP). The E-4A/B will provide the National Command Authorities and Strategic Air Command with a significantly improved and highly survivable airborne command, control, and communications center that would operate during all phases of a general war. The three interim E-4As achieved operational status at Andrews AFB in support of the National Command Authorities in September 1975. The fourth aircraft, a Boeing 747, was accepted by the Air Force in August 1975. Advanced command, control, and communications equipment is being developed for integration into this aircraft.

EF-111A Tactical Jamming System (TJS). A 38-month contract was awarded in January 1975 for two prototype EF-111A TJS aircraft for research, development, test, and evaluation. When developed, the EF-111A will be used primarily to support counter-air, close air support, interdiction, and reconnaissance sorties. The peacetime mission will be to provide worldwide training for air defense and tactical forces. The preliminary design phase was completed in September 1975 and aerodynamic flight testing began the next month.

Aeronautical Research and Technology

Aircraft Structure and Materials Technology. Significant progress was made in 1975 in advanced composite structures and materials technology by all three services.

The Air Force completed a program using the F-15 wing as the design baseline to demonstrate the technology in construction of primary structures. The test wing had a composite torque box and metal leading and trailing edges and tips and control surfaces. Extensive static-load testing and 500 hours of fatigue testing showed that the full-scale composite wing satisfied all structural requirements imposed by the F-15 design. A weight saving of 18 percent, or 170 kilograms, over the existing metal torque box was achieved. Another project using the YF-16 forward fuselage as the design baseline component is nearing completion. The composite parts are collectively 21 percent lighter than the replaced metal items. The horizonal stabilizer torque box of the B-1 aircraft, the largest advanced-composite article to date, is slated for testing during 1976.

The Navy components that have completed laboratory static and fatigue tests include the S-3 spoiler, F-14 overwing fairing, F-14 main landing gear door, and a wing for the BQM-34E supersonic target vehicle. An additional 70 composite components are being fabricated for operational aircraft and will be monitored over a five-year period to answer critical technical questions as well as to increase confidence with graphite composites. The Navy also began development of a fiberglass composite rotor blade to replace the H-46 metal rotor blade. The fiberglass rotor blade is designed to be corrosion resistant and to be insensitive to small defects.

The Army has designed a monocoque-sandwich aft fuselage for future tactical and utility helicopters. Indications are that composite rotor blades and airframe structures can provide significant cost advantages and greatly reduced radar reflectivity. Development of composite materials for aircraft windshields using surface-coated polycarbonates, glass/polycarbonates, and transparent crystallized glass will produce windshields that are more abrasion and impact resistant and also have improved ballistic properties. Finally, the Army has developed a process for fabricating integral sheet-stringer-frame structures from composite materials, applicable as a hybrid composite design for a CH-53 fuselage.

Advanced Helicopter Rotor System. The Advanced Helicopter Rotor System is intended to prove the flight feasibility of the Circulation Control Rotor (CCR) concept with a full-scale system to establish design-to-cost goals and trade-off parameters. CCR is to be capable of replacing all existing helicopter rotor systems without any inherent operational limitation. The CCR system operates on the basic principle of a rotor blade with a trailing-edge boundary-layer blowing system. Cyclic control is provided by air modulation, eliminating many conventional rotor-head complexities and reducing vibration levels. In January 1975 a contract was awarded for a 42-month, incrementally-funded program to demonstrate CCR feasibility.

Helicopter Noise Research. Acoustic detectability is a major factor in helicopter survivability. A new technique has been developed for measurement of helicopter far-field impulsive noise in flight. New data have been obtained, for example, on noise in the "blade-slap" condition. Other measurements made in wind tunnels agree with flight data. These results will expand the data base for helicopter noise-reduction efforts.

Advancing Blade Concept (ABC) Demonstration Vehicle. The ABC development program was initiated by the Army in December 1971. The program includes fabrication and flight test of two aircraft to verify and demonstrate the concept. The ABC demonstrator is equipped with two coaxial, counter-rotating hingeless rotors. This concept offers several potential advantages over conventional rotor systems: problems of retreating blade stall would be largely eliminated, maneuver capability significantly enhanced, and maintenance eased. The first aircraft was involved in an accident in August 1973. Following a comprehensive accident investigation, the program was restructured and flight testing was resumed in July 1975 with a modified flight control system. The current test aircraft has flown over 12 hours at speeds up to 60 knots.

Research in Aircraft Propulsion. A major success in the Army's aeronautical propulsion research program has been the development of efficient methods of analytical design for small high-temperature combustors. Two combustors designed to reduce levels of emissions have demonstrated a 50 percent reduction. Another success was the achievement of single-stage pressure ratio of 10:1 at 78.4 percent efficiency for the 3- to 5-pounds-per-second class of compressors. The increase in compression ratio means at least a 20 percent reduction in specific fuel consumption for future gas turbines.

Engineering development of the T700 engine, which began in March 1972, is on schedule. The preliminary flight-rating test was completed in July 1974. Emphasis on ease of maintenance, plus its modular aspect, will significantly reduce costs over the lifetime of this engine.

Initial results from the Small Turbine Advanced Gas Generator (STAGG) Program indicate that increased specific power and reduced specific fuel consumption have been achieved. STAGG technology will support future Army aircraft and auxiliary power plants of the 200-to-1000 shaft-horsepower range.

One low-emission combustor has been incorporated into an updated T63 engine to increase tolerance to water injection, which had previously caused flameout. The XT701 engine, which was selected to power the prototype heavy-lift helicopter, completed a preliminary flight-rating test on schedule in March 1975. A T39 aircraft with JT12 engines was test-flown from Ohio to Texas on JP-4 fuel made from shale oil—the first turbine aircraft to fly on this synthetic fuel. A joint Air Force/Navy program was initiated for an engine to demonstrate turbofan technology necessary for powerplants of the next decade.

U.S. Army Avionics. Aircraft at four major Army installations with the highest density of air traffic have been equipped with Proximity Warning Devices (PWD). The pilot receives a visual and aural warning whenever an "intruder" enters a certain volume of airspace around his own aircraft. There have been no mid-air collisions between PWD-equipped aircraft. The Army, with the other services and the FAA, is studying a national collision avoidance system.

A Laser Obstacle Terrain Avoidance Warning System (LOWTAWS) has been fabricated to make tactical nap-of-the-earth flight safer and more effective by detecting terrain variations and obstacles. Flight tests are planned for Fiscal Year 1976.

Finally, development of phase-front-homing technique will be applied to the AN/ARC-114 VHF/FM radios now installed in Army aircraft. Modification of circuitry in the radios and the use of a small antenna adapter will enable the pilot to home to a tactical FM transmitter with significant improvement in accuracy and in "flyability" of the displayed indications. Other benefits associated with phase-front-homing include less complex antennas, less concern for antenna placement, and potential use of the modified radio as a low-cost hover sensor and automatic direction finder.

Tactical Airborne Signals Exploitation System (TASES). The Navy's TASES program is developing a multi-sensor, tactical electronic warfare support system for carrier-based aircraft. Its primary task will be to provide real-time tactical electronic warfare and surveillance information to the operational commander at sea. Electronic, communications, infrared, and radar sensors will be integrated into an S-3A aircraft. The three crewmen will be assisted in processing and correlating intercepted data by a highly automated sensor management system. TASES is intended to cope with the complexities of the electromagnetic environment projected for 1980-1990.

Relationship with NASA

Aeronautics and Astronautics Coordinating Board (AACB)

The AACB, the principal formal coordinating body between DOD and NASA, met three times in 1975.

The Aeronautics Panel of the AACB reevaluated the National Aeronautical Facilities Program in the light of rapidly escalating costs. The primary purpose was to determine the feasibility of a single, high-Reynolds-number, transonic tunnel to meet both research and development needs. The final report concluded that a single National Transonic Facility (NTF) was feasible. On June 2, 1975, the AACB Co-chairmen signed a memorandum agreeing that NASA would provide the facility. The NTF is included in NASA's current funding plans. The two other facilities in the National Aeronautical Facilities Program are the NASA 40-x-80-foot subsonic wind tunnel modification and the Air Force Aeropropulsion System Test Facility (ASTF). ASTF is in the DOD funding plan.

The new minimum cost concept for the Space Shuttle baseline launch and landing facilities for Vandenberg AFB was reviewed by the Board. The use of Edwards AFB as the primary landing site was shown to be less effective and more costly than use of Vandenberg AFB. A Memorandum of Understanding on Management and Operation of the Space Transportation System (STS) was signed by the Air Force and NASA; it establishes the broad policies that will govern relationships between DOD and NASA relevant to the development, acquisition, and operation of the national STS. Space Shuttle's payload environment problems, alternative solutions, and payload costs, along with Shuttle operating costs, were considered by the Board.

Joint Programs

Rotor System Research Aircraft (RSRA). This joint Army-NASA program will evaluate the potential of promising new advanced rotor concepts, as well as verify numerous areas of supporting research and technology. The design of the research aircraft is essentially completed, except in two areas. First, analysis and simulation studies using wind tunnel data indicated the need for a fail-operational stability augmentation system to ensure flight safety. Second, extensive analysis of the rotor Active Isolation/Balance System indicated that changes were desirable in the proposed configuration to enhance adaptability to a wide range of advanced rotors. First flight of the RSRA is scheduled for July 1976.

Tilt Rotor Research Aircraft. The Tilt Rotor Research Aircraft, a joint Army-NASA program, will lead to a complete flight demonstration of the tilt-rotor concept and an evaluation of tilt-rotor capabilities with respect to mission performance, survivability, and safety. On August 1, 1973, a contract was awarded for the design, fabrication, and testing of two XV-15 Tilt Rotor Aircraft. The fuselage structure for the first aircraft has been completed and systems are being installed. Many other components, including the Automatic Flight Control System, engines, and major wing and blade structures have been completed. Powered tests of the rotor and controls are scheduled to be conducted in the NASA Ames 40-x-80-foot wind tunnel late in 1975 to explore autorotation characteristics and expand the boundaries of previous tests of conversion from hover to forward flight. Rollout of the first XV-15 will occur in early 1976, to be followed by extensive ground testing and wind tunnel tests. First flight is scheduled for 1977.

Rotor Flow Field Test Techniques. Rotor downwash, trailing tip vortex, and bound circulation on the blade of a teetering rotor model have been measured in the NASA Ames 7-x-10-foot wind tunnel with a laser velocimeter. Color Schlieren techniques have been developed and demonstrated. A doppler laser has been used to make wake measurements behind the oscillating yaw rig in the NASA Langley 7-x-10-foot wind tunnel. Oscillating airfoil equipment has been designed and fabricated for test in the Langley transonic wind tunnel. A program has been initiated to provide measurement of local rotor-blade angle of attack in flight and various sensors have been studied for applicability to the research. Advanced laser velocimeter methods that provide three-dimensional measurements in the rotor flow field are being investigated. All these research investigations in rotor flow field test techniques are joint Army-NASA efforts.

X-24B Lifting Body. The X-24B was built by a joint Air Force-NASA program to explore the low-speed flying qualities of a hypersonic lifting body. After 33 flights, this program was concluded successfully during 1975.

IV

Department of Commerce

Introduction

The Department of Commerce program in aeronautics and space activities is carried out by the National Oceanic and Atmospheric Administration, the National Bureau of Standards, the Office of Telecommunications, the Maritime Administration, and the Bureau of the Census.

The broad goals of these agencies include programs to ensure that the environment and its resources are wisely used; to strengthen, advance, and facilitate application of science and technology for the public benefit; to improve ship communications, navigation, safety, and operations; to provide specialized engineering, management, and advisory assistance to other Federal agencies in telecommunications applications; and to provide information on population trends, urban growth, and internal demography of national land areas.

These goals have been or are being reached by establishing and maintaining an operational satellite system; by continuing programs for monitoring and predicting marine resources; by monitoring our marine environment continuously with improved sensors on ships, aircraft, and satellites; by improving our weather observations and forecasts through the use of automated observation stations, improved radar systems, and continued atmospheric research programs; by conducting research in weather modification; by improving data collection, processing, and dissemination techniques; by providing basic measurement and calibration methods for operating technical systems and for engineering data on the design and construction of sophisticated space and aeronautics equipment; by installing, testing, and evaluating shipboard satellite equipment; by conducting electromagnetic wave propagation studies for the improvement of aerospace communications; and by applying imagery to demographic studies.

Satellites in Environmental Monitoring and Prediction

Environmental Satellite Operations

On January 1, 1975, the National Environmental Satellite Service (NESS) of the National Oceanic and Atmospheric Administration (NOAA) was operating four polar-orbiting satellites: Essa 8 of the TIROS Operational Satellite (TOS) series and NOAA-2, NOAA-3, and NOAA-4 of the Improved TOS (ITOS) series. Essa 8 has been providing data to users of Automatic Picture Transmission (APT) on a worldwide basis for nearly seven years. NOAA-4 has been the primary global data-gathering satellite throughout 1975, NOAA-3 was placed on operational standby in December 1974 and serves as a backup to NOAA-4, and NOAA-2 was deactivated on January 30, 1975. ITOS-E2 (to be named NOAA-5 when in orbit) was scheduled for launch in July 1975. Its launch was deferred month by month because NOAA-4 continued to operate satisfactorily, and NOAA-3 was an adequate backup. ITOS-E2 will be launched when needed.

On February 6, 1975, NASA launched the Synchronous Meteorological Satellite, SMS-2, the second and final prototype for the Geostationary Operational Environmental Satellite (GOES) system. SMS-2 was placed in geostationary orbit, 35,785 kilometers above the equator at 115° West longitude. The instrument and communication systems are identical to those on SMS-1: a Visible and Infrared Spin-Scan Radiometer (VISSR), a Space Environment Monitor, a Data Collection System (DCS), and a Weather Facsimile broadcast system. SMS-1, located over the equator at 75° West longitude, and SMS-2, together provide a viewing of the area from 70° N to 70° S and westward from 5° W to 175° E. Full-disc pictures are acquired at 30-minute intervals from the VISSR instruments on each of the spacecraft. This permits nearly continuous viewing of severe storms and helps weather forecasters to provide the public with timely warnings.

Goes 1, the first NOAA operational version of SMS, was launched on October 16, 1975, into geostationary orbit 35,769 kilometers over the equator at 55° West longitude. Goes 1 carries the same instrument and communication systems as SMS-1 and 2. Late in 1975, SMS-2 was moved to 135° W, arriving on station December 19, 1975. Goes 1 would move to 75° W, replacing SMS-1 as the eastern operational satellite, in January 1976. SMS-1 would then move to 105° W in February 1976 and be placed on operational stand-by.

Development is continuing on the third generation of polar-orbiting satellites, the Tiros-N series. These satellites, destined to replace the current ITOS system, will provide more accurate data for environmental monitoring and prediction. The instruments to be included are the Advanced Very High Resolution Radiometer, the TIROS Operational Vertical Sounder, the Space Environment Monitor, and the Data Collection and Platform Location system. The NASA prototype of Tiros-N is scheduled for launch in early 1978.

Because of the higher data rate, the fully digital data system, and the increased operational demand for timely delivery of processed data, a new ground system is needed to accommodate the data from the Tiros-N. This ground system, incorporating as many parts of the ITOS system as practicable, will consist of two major subsystems: the Data Acquisition and Control Subsystem (DACS) and the Data Processing and Services Subsystem (DPSS). DACS comprises the equipment for the Wallops, Virginia, and Gilmore Creek, Alaska, Command and Data Acquisition (CDA) stations; the Satellite Operations Control Center (SOCC); and the interconnecting communications between the CDAs, SOCC, and DPSS. DPSS consists of NESS data processing facilities and interfaces with the NOAA large-scale central computing capability.

Uses of Environmental Satellite Data

Vertical Temperature and Wind Profiles. A long-term goal of NESS is to develop a system for monitoring global atmospheric temperature and wind profiles that is operationally independent of the worldwide radiosonde network. Vertical Temperature Profile Radiometer (VTPR) data obtained from NOAA satellites have contributed toward this goal. VTPR soundings are used routinely in the National Meteorological Center's numerical weather prediction program. NESS continues research toward development of satellite instruments and analysis methods that can determine the vertical temperature structure of the atmosphere and the global distributions of atmospheric constituents such as water vapor, carbon dioxide, and ozone, all of which influence the accuracy of measurements. The High Resolution Infrared Radiation Sounder (HIRS) experiment was carried on Nimbus 6, launched on June 12, 1975. The HIRS is a third-generation instrument with new features, one of which is measurement in the 4.3-micrometer CO_2 band. This should greatly improve soundings of the atmospheric temperature to the 40-kilometer level and of the water vapor profile to the 10-kilometer level.

Both SMS-1 and SMS-2 visible and infrared images are being used to derive wind vectors from cloud motions. Infrared data are used to determine cloud-top temperatures and cloud heights, which enable wind vectors to be assigned to their proper atmospheric level. Comparison of satellite-derived wind vectors, produced operationally, with those processed on an experimental basis agree within reasonable tolerances. The low-level wind values generally agreed within 1 meter per second while high-level winds agreed within 3 meters per second.

Research is being conducted to develop better techniques to measure winds from geostationary infrared images of cloud motions. Much of the effort is concentrated on establishing the heights of clouds through accurate determination of the equivalent blackbody temperature.

Monitoring Global Radiation. The Earth Radiation Budget experiment, carried on Nimbus 6, is designed to measure with high accuracy the radiation of the Sun and Earth. A terrestrial radiation budget can then be determined on both the synoptic and planetary scales. The measurements will serve as an initial bench mark for the long-term monitoring of global radiation.

Environmental Warning Services. The launch of SMS-2 increased the primary warning platforms to a two-spacecraft system. In addition two new Satellite Field Services Stations (SFSS) have been established. In July 1975, an SFSS began operations in Honolulu using data from the SMS-2 spacecraft, and in November an SFSS was established at Anchorage, Alaska, to use data from the polar-orbiting satellites via the Gilmore Creek CDA. Data are received at the Gilmore Creek CDA from an average of seven orbits each day.

Full-disc or sectors of VISSR images received at each SFSS are sent to Weather Service Forecast Office (WSFO) facilities. Twenty-nine WSFO/GOES facilities were commissioned in 1975, completing a planned network of 50 National Weather Service field offices to receive and use GOES pictures. Forecasters are using the pictures to improve short-term forecast and advisory services to the public, aviation, and shipping. The opportunity to receive the data distributed to any SFSS has been extended to television stations, universities, local governments, and Federal agencies. This system, called GOES-TAP, allows the user to receive any one of the standard sectors available to the SFSS every 30 minutes.

The SMS/GOES satellites are equipped with a Data Collection System (DCS) to collect and relay environmental data sensed by widely dispersed surface platforms such as river and rain gages, seismometers, tide gages, buoys, ships, and automatic weather stations. Each spacecraft can accommodate data from

10,000 or more individual observing platforms every six hours. Platforms transmit sensor data by radio, either at scheduled intervals or upon interrogation from the satellite. Platforms also may operate in an emergency alarm mode, during which a signal is transmitted immediately whenever an observational parameter exceeds a preset threshold value. Data received by the satellite are transmitted on S-band to the Wallops CDA Station and relayed to the World Weather Building, Camp Springs, Maryland. From here the data are disseminated by paper tape fed into a telephone system using commercial circuits. The GOES DCS began providing service to users on August 18, 1975; currently services are provided to various agencies in the United States and Canada.

In March 1975, France began relaying Vertical Temperature Profile Radiometer data to the United States operationally. These data are from NOAA-4 orbits that do not pass within range of the United States CDA stations.

Tornadoes and severe thunderstorms can frequently be predicted shortly before they occur by noting the intersection of lines of convection on SMS high-resolution satellite pictures. Experiments in using satellite pictures at five-minute intervals instead of the usual thirty-minute interval hold hope for considerable improvement in tornado warning.

Determining Ocean Conditions. Seasat-A, an an oceanographic satellite being developed by NASA, is scheduled for launch in 1978. NOAA has begun to plan experiments that will exploit Seasat-A data for satellite altimetry; sea and lake ice monitoring; geodesy; ocean tides, waves, winds, currents, and temperatures; and meteorology.

NOAA-4 Very High Resolution Radiometer (VHRR) infrared images are being used to produce weekly composite charts that depict water masses and thermal fronts in the Gulf Stream along the east coast of the U.S. These charts are sent to users over the National Facsimile network and by mail. The National Weather Service also uses these data to prepare the Gulf Stream Wall Bulletin, which is broadcast to the public by radio. Researchers are using these infrared data in their studies of warm anticyclonic and cold cyclonic eddies associated with the Gulf Stream. The satellite measurements provide an instantaneous view of sea-surface temperature patterns that cannot be identified by *in-situ* data alone. SMS-1 infrared images of Gulf Stream features also are put in time-lapse movies that enable scientists to continually monitor motions of thermal features in and adjacent to these currents. Further exploitation of SMS data is expected to permit monitoring of turbidity fronts, which in some areas are strongly correlated with fish concentrations. Shipping interests are using Gulf Stream data to route their ships along the east coast, minimizing transit times and saving fuel. The Coast Guard also is using this information in computerized search and rescue operations.

The Coast Guard uses SMS images to determine the presence of low clouds and fog over the U.S. portion of the International Ice Patrol area. With this information, unproductive ice reconnaissance flights have been cancelled or redirected.

Composite ice charts of Alaskan coastal waters, based on infrared imagery, are produced and disseminated weekly over National Facsimile and by mail. The severe ice conditions along the north coast of Alaska during the summer of 1975 were of special interest. Numerous barges carrying supplies to the pipeline project had difficulty in reaching Prudhoe Bay. The Fairbanks Weather Service Forecast Office used VHRR images in developing ice advisories and forecasts to assist this shipping. NOAA-4 images also were used during 1975 in helping to free the U.S. Coast Guard icebreaker *Glacier* and the Argentinian ship *San Martin* from the Antarctic ice pack.

NOAA satellite images and remotely sensed data from aircraft were used to support the Arctic Ice Dynamics Joint Experiment. Studies are being conducted to relate ice thickness to infrared and microwave radiometer measurements.

Determining Lake Conditions. NOAA-4 VHRR images in the visible part of the spectrum were used to produce the Great Lakes ice charts, transmitted twice weekly on National Facsimile. Use of these charts to route ships through the ice is credited with extending the 1974-75 shipping season in most of the Lakes by more than 30 days. Ships were able to operate between Chicago and Duluth the entire 1974-75 winter season.

At the same time, NOAA, NASA, and the Coast Guard conducted a joint remote-sensing ice reconnaissance experiment. A C-130 aircraft, equipped with Side-Looking Airborne Radar, recorded ice conditions over the Great Lakes and relayed these data in near-real time to the Ice Central in Cleveland via the GOES Data Collection System. This timely reception of data allowed a more rapid dissemination of ice information to the ships.

Studies of Great Lakes whitings (chemical precipitation of calcium carbonate) have been expanded to include frequency of occurrence and areas affected. One of nature's largest dye operations, the whiting provides the limnologist with an ideal tracer for assessing horizontal circulation.

In 1975, Great Lakes surface temperature charts were prepared from satellite infrared data for the first time. These charts are mailed biweekly to the Eastern and Central Regions of the National Weather Service for use in forecasts of Lake freezeup and in upwelling studies.

Determining Hydrological Conditions. Quantitative estimates of snow cover derived from VHRR and GOES VISSR data were extended to 18 river basins in the United States and 4 in Canada. Also radio transceivers were installed on river and rainfall gages at 44 remote locations. Data from these platforms are obtained by interrogation by the GOES Data Collection System. The ability to make earlier assessments of rainfall and snow cover enables the National Weather Service's (NWS) River Forecast Centers to improve their river forecasting and flood warning services and their estimates of water supplies.

It is difficult to determine whether snow cover in forested river basins differs in depth, area, and water equivalents from snow cover in non-forested areas. Remote sensing images from aircraft are being compared to *in-situ* measurements to determine the spectral reflectance of snow in forest-covered areas. The NWS Hydrologic Research Laboratory also is conducting airborne gamma radiation surveys of snow-covered areas to obtain reliable, current information on snow-cover water equivalents for use in NWS forecasts of snowmelt runoff.

Monitoring Agriculture Conditions. A joint United States-Mexico program to eradicate screwworms throughout Mexico is using NOAA satellite temperature and moisture data. The object of the program is to push the screwworm barrier, now along the U.S.-Mexican border, southward. The barrier is maintained by continously seeding the area near this barrier with sterile flies. Studies are being conducted to see if there are optimum times, based on temperature and moisture conditions, for breeding so the sterile flies can be introduced at selected times, rather than continuously, to reduce program costs.

Pollution Monitoring. From April 7 to 17, 1975, NOAA and NASA conducted an extensive experiment in the New York Bight using Landsat, NOAA, and SMS satellites, three research airplanes, four helicopters, and one research ship. Although similar to the 1973 field program, the effort covered a larger area and included more measurements. This experiment was designed to demonstrate the capability of remote sensing methods to determine water circulation, water mass characteristics, and amounts of suspended particulates, chlorophyll-a, and pollutants such as acid waste and sewage sludge.

Fisheries. The Inter-American Tropical Tuna Commission continues to study the use of NOAA satellite infrared data for locating and mapping oceanographic fronts and upwelling areas related to the distribution and abundance of several commercially important species of fish.

The National Marine Fisheries Service (NMFS) is using geostationary-satellite data to study the relationship of Gulf Stream meanders in continental shelf waters to the presence of biological organisms. Satellite-derived and *in-situ* surface temperature data are used to determine the relationship between sea temperatures and coastal upwellings and fish migrations.

NMFS, state governments, and private industry are conducting a 22-month investigation to determine the feasibility of using satellite data to improve the management and use of coastal fishery resources in the northern Gulf of Mexico. Menhaden and thread herring are the target species. Data from SMS, NOAA, and Landsat satellites and aircraft remote sensors will be correlated with sea-truth data to provide NMFS with increased knowledge of coastal water ecology.

Environmental Monitoring Using Data Buoys. The NOAA Data Buoy Office (NDBO) is developing prototype buoy systems for the acquisition of environmental data. Development has started on an air-deployable ice buoy and an oceanographic and meteorological ice buoy. The data acquired will be used in studies of ice behavior on the continental shelf and elsewhere. The air-deployable buoy will be placed at the ice edge to measure ice motion. The second type will measure oceanographic and meteorological parameters. Data from these buoys are to be relayed to analysis centers through the Nimbus 6 satellite.

Development was started on drifting buoys for use in the open ocean. The impetus for a drifting buoy capable of measuring simple environmental parameters comes in part from the Global Atmospheric Research Program. Prototype drifting buoys are now under test, using the Nimbus 6 satellite to relay data. These open-ocean drifters also can be used by oceanographers for tracking surface currents.

Other Satellite and Space Applications

International Cooperation

Sharing Data. Under the Voluntary Assistance Program of the World Meteorological Organization, the NWS installed ground stations for Automatic Picture Transmission (APT) in Costa Rica, Barbados, and the Bahamas. In addition APT equipment was sent to Cambodia. This makes a total of 25 countries that have received APT facilities. A new ground receiver station, designed by NASA to receive the APT broadcasts from polar-orbiting satellites and S-band Weather Facsimile broadcasts from geostationary satellites, was installed in Trinidad for operational test and evaluation.

NESS and the Office of Foreign Disaster Relief Coordinator of the Department of State, Agency for International Development (AID), initiated a cooperative program in which AID is advised daily of weather conditions that could lead to natural disasters anywhere around the world. This information, based on satellite images, alerts the AID office to probable requests for assistance.

The exchange of environmental satellite data between Washington and Moscow continues. The U.S. receives data from Meteor 18, 21, and 22, and the U.S.S.R. receives data from NOAA-4. The most recent launch by the Soviets was Meteor 22 on September 17, 1975.

Demographic Studies. The Bureau of the Census, using AID funds, continues to study the applicability of Landsat 1 and 2 data to demographic studies and other census operations in Kenya and Bolivia. These images are the base for developing a national mosaic for statistical data mapping and analysis and for preparation of annotated photomaps for field use. Mapped Landsat images and ground-truth data also are being used to develop population estimates and distribution models.

The Census Bureau continues to study the application of satellite data to domestic census programs. Landsat 1 computer-compatible tapes and an interactive display and manipulation system were used experimentally to derive preliminary urbanized-area boundaries. Results indicated that a preliminary urban-rural boundary zone can be established from the Landsat images; the method should increase efficiency and reduce the cost of this Census Bureau program. These investigations are being conducted to ascertain the nationwide applicability of this approach. The incorporation of Landsat and other forms of imagery for the preliminary identification of small, unincorporated clusters also has been useful. Aggregates in the 600-to-1500 population range generally can easily be identified. It appears that satellite images will be helpful in the development of a nationally consistent approach to delineating unincorporated places.

Weather Modification

The NOAA Atmospheric Physics and Chemistry Laboratory (APCL) conducted an aircraft flight program to measure electric fields over the Kennedy Space Center lightning warning network. The findings were used to modify existing rules about lightning hazards during spacecraft launches. APCL personnel were on hand to advise NASA on the hazards of electric fields in clouds over the launch site and the danger of lightning triggered by the launch vehicle during the Apollo-Soyuz and Viking launches.

The NOAA National Hurricane and Experimental Meteorology Laboratories continued to use satellite data to study the modification of hurricanes and tropical convective clouds. Satellite data were used to estimate winds from cirrus cloud motions, to evaluate the accuracy of estimating hurricane and typhoon position and intensity, to evaluate rainfall from convective clouds by comparing satellite images with radar data and surface rainfall, and to determine surface thermal properties of the Florida peninsula for use with numerical models of the sea breeze.

Ship Navigation and Communications

The Maritime Administration used NASA's ATS-5 and 6 satellites to conduct experiments for ship navigation and communications. Techniques for two-satellite ranging were evaluated, and satellite capability for teleprinter, facsimile, and voice transmission was demonstrated. These experiments prove that satellites can extend common terrestrial communication services to ships at sea. Experiments also were conducted in telemetering medical data to ships at sea. These services can be valuable for improving management and operating economy of merchant vessels.

Determination of the Earth's Shape and Gravity Field

The National Ocean Survey (NOS) continued to prepare computer programs for the analysis of altimetry data from the Geos 3 satellite. New mathematical methods were devised for measuring the Earth's gravity field. Analysis was begun on determination of accurate orbits for the Seasat satellite, which will carry an altimeter with an expected 10-centimeter precision.

NOS initiated studies of new methods to determine geodetic control and to monitor temporal variations in horizontal and vertical positions, pole locations, and Earth rotation. Doppler observations from the Navy navigation satellites were obtained at 71 stations throughout the United States, at 6 stations emplaced near the Cook Inlet area of Alaska to support pre- and post-earthquake horizontal positioning, and at 10 stations placed on offshore oil platforms in the Gulf of Mexico to extend the offshore horizontal positioning network.

NOS completed work on the network of North American station locations. The adjustment covers the North American continent and includes ties to Greenland, Iceland, and Norway. Results showed an average standard deviation of less than three meters per station coordinate.

Marine Surveys and Maps

NOS investigated the feasibility of using Skylab photography in analytic aerotriangulation procedures. The Coastal Mapping Division identified 29 photo control points of known position and elevation on a strip of 12 photographs along a 570-kilometer track extending from Charlotte, North Carolina, to the

Rappahannock River in Virginia. The photo coordinates, processed through an established analytic aerotriangulation system of computer programs, showed a root-mean-square error of 15 meters in horizontal position; the maximum observed error was 25 meters.

A remarkable ability to penetrate water is a property of several film emulsions used in aircraft-mounted cameras. The resulting dramatic presentation of submerged detail makes photogrammetric bathymetry an excellent alternative tool or supplement for mapping the seabed in shoal and moderate-depth waters. Natural-color film emulsion has the deepest water penetration, nearly 23 meters in clear waters and 2 to 3 meters in turbid coastal waters. Natural-color film is ideal for photointerpretation of underwater details. False-color infrared emulsion can penetrate clear water to a depth of nearly 8 meters; bottom details are nearly as sharp as on natural color.

Satellite Communications

The Office of Telecommunications (OT) has developed a 125-station satellite communications network model for the U.S. Postal Service to use in planning its electronic message system. The model, which permits estimation of system characteristics and message delay, was used with traffic loads of 90 million messages per day to estimate typical delays. In a single-satellite network, typical delays are about three seconds per message.

Rapid changes in ionospheric brightness limit the data rate of Earth-space telecommunication systems. OT participated in a program with other government agencies to determine the time and space variations of these scintillations, to relate them to predictable or observed geophysical parameters, and to use them to determine degradation to be expected in current or planned satellite communication systems.

OT has made measurements to determine the attenuation of UHF radio signals by buildings, for use in planning the feasibility of a future direct-broadcast, disaster-warning satellite system. Attenuation directly influences the size, weight, and power requirements for the spacecraft and the cost of the receiving unit. OT designed and assembled the instrument system to measure attenuation as a function of frequency, type of building construction, elevation angle, and climate. The signals for these test measurements were transmitted from the ATS-6 satellite.

Time Services

The National Bureau of Standards (NBS) began an advanced experimental time-dissemination service via the GOES satellite system. The signal, a time-of-day code transmitted from NOAA's Wallops CDA Station, is relayed nearly continuously by the GOES satellite to about one third of the Earth's surface. NBS also has developed a technique for generating 30-day predictions of a satellite's position in space. These data are broadcast with the time code. The uncorrected time-of-day information is accurate to about 1 millisecond. If this is inadequate, the coded satellite position prediction may be used to determine path delay and increase the accuracy to within 100 microseconds. There will be widespread use of this service in communications, position location, monitoring of seismic events, and scientific experiments.

Lunar Ranging

NBS has participated in determining new geophysical information from analysis of laser distance measurements to the Apollo retroreflectors on the Moon. The value of the gravitational constant G times the mass of the Earth has been measured with an accuracy of 2 parts in 10^{7}, and the location of the center of mass of the Moon has been determined to 25 meters. Measurements of the Earth's rotation have been obtained. The angular position has been determined to an accuracy of 20 centimeters or better at the equator. The results permit a careful investigation of short-period interchanges of angular momentum between the atmosphere and the solid Earth.

The National Ocean Survey and NASA's Johnson Space Center completed work on the Selenocentric Reference System Project. A simultaneous adjustment of all 1244 usable photographs from the Apollo 15, 16, and 17 missions was completed. The horizontal positions and elevations of more than 90 percent of 5325 lunar-surface features were determined to within 45 meters.

Space Support Activities

Apollo-Soyuz Support

The National Weather Service provided forecasts for the Apollo-Soyuz Test Project, made daily cloud-cover predictions to aid in scheduling photography from Landsat, provided sea-truth support for Geos 3, and provided forecasts for NASA's Earth Resources aircraft program.

The NOAA Space Environment Services Center (SESC) provided warning and hazard evaluation of solar proton radiation to NASA for the Apollo-Soyuz joint mission. Warnings were coordinated with the Hydrometeorological Service of the U.S.S.R. This project included exchange of data on solar emissions and radiation levels in the near-Earth environment.

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Space Environment Services

The SESC provided forecasts and warnings of adverse environmental conditions, including geomagnetic storms and polar cap absorption events, to communication satellite operators, electric power utilities, geophysical exploration groups, pipeline companies, scientific experimenters, the Federal Aviation Administration, and Air Force and Navy commands responsible for military communication and navigation systems. The year was especially marked by the disruption or temporary loss of operation of several satellites because of high-voltage arcing. Geomagnetic disturbances occurring near the end of the solar activity cycle, when flare activity is near minimum, appeared to be the main cause of these outages. SESC used data from the global solar flare patrol, from satellite sensors, and from terrestrial magnetometers. Data obtained from the Space Environment Monitor systems aboard SMS-1 and SMS-2 provided real-time information on solar X-rays, solar particle emissions, and the near-Earth geomagnetic field. Other data were obtained from the NOAA, Vela, and Pioneer satellites.

Space Processing Research

NBS continues to provide support of NASA's Space Processing Program. The work deals with experimental and theoretical studies of the possible effects of the absence of gravitational forces on preparation of materials when such forces may be important in reducing perfection or purity. Areas of work are Czochralski crystal growth, evaporative purification, composite materials, melt shape in zero-g, vapor transport synthesis of single crystals, and Marangoni flow

Measurements and Calibrations

The NBS Electromagnetics Division has pioneered the development of accurate and powerful near-field measurement techniques for directive microwave antennas. It is possible to accurately measure the amplitude and phase of any desired number of points over a rectangular lattice within one or two meters of the antenna in the 1- to-15-GHz range. These data are used to compute complete antenna characteristics such as gain, pattern, polarization, and side-lobe levels. Since laboratory-type control is possible and the errors associated with conventional far-field measurements are avoided, high accuracy is achieved. The near-field approach is particularly valuable for electrically large antennas that cannot be managed on existing far-field ranges and in situations where it is necessary to avoid interference, physical contamination of satellite or space systems, and atmospheric absorption. The method also can be applied to many antennas mounted in operational configuration, such as on a spacecraft or airplane. In such cases, the computed antenna characteristics include the effects of the mounting structures. A recent application was the measurement of a NASA radiometer antenna of the type used on Skylab and for the Earth Resources program. Accurate knowledge of the resistive loss of the antenna is needed for interpretation of the radiometer data. This measurement proved that the near-field method can determine loss to at least the same accuracy as other methods and provide complete gain, pattern, and beam efficiency data which are difficult to obtain by other means.

Space and Atmospheric Physics Research

Space Physics

Astrophysics. The Joint Institute for Laboratory Astrophysics, a cooperative effort of NBS and the University of Colorado for the study of atomic physics and astrophysics, has been developing plasma-diagnostic and model-atmosphere techniques useful in analyzing ultraviolet spectra. Physical properties of structures in the solar chromosphere and the propagation of waves in the solar photosphere and chromosphere are being studied by experiments on OSO-8. Solar observations from OSO-7 and Skylab also are being analyzed to study the formation of neutral and singly ionized helium spectra in the ultraviolet portion of the digit spectrum.

Interplanetary Physics. The NOAA Space Environment Laboratory (SEL) continued to develop time-dependent numerical codes to forecast the arrival at Earth of material ejected during solar flares and to simulate space probe data associated with shock waves. The theory of the nonlinear interactions between high- and low-speed solar wind streams was extended to small amplitude disturbances and to the solar equatorial plane.

Cooperative research of SEL with the University of Iowa and the Applied Physics Laboratory of Johns Hopkins University demonstrated the possibilities for predicting ionospheric and magnetic disturbances several hours in advance. Signals received by a large radiotelescope at Clark Lake Observatory, California, exhibit scintillations caused by irregularities in the interplanetary electron density, which in turn are caused by propagating shock waves from solar flares and complex interplanetary stream interactions. These data, supplemented by solar and interplanetary data, can be used to track shock waves and solar streams in the interplanetary medium.

Atmospheric Physics

Ionospheric Physics. The radio beacon experiment on the ATS-6 satellite and the X-ray measurements from SMS-1 and 2 have provided SEL with the highest resolution and absolute accuracy ever achieved in total-electron-content measurements and the greatest resolution in intensity and largest dynamic range for broadband X-ray monitoring. The ATS-6 measurements permit the columnar ionospheric electron content up to 2000-kilometer altitude to be separated from the total content up to the satellite altitude. This can be done with sufficient accuracy to determine the residual plasmapheric content between 2000 kilometers and the satellite; such data are used for studies of diurnal, seasonal, and storm variations. The SMS-1 and 2 measurements have permitted study of the time rate of change of the solar soft-X-ray flux and its relation to the impulsive solar radio bursts at microwave frequencies. These data are being used to model and verify the effects of solar flares on the E and F regions caused by broadband and impulsive extreme-ultraviolet radiation.

The NOAA Aeronomy Laboratory has recently begun using a VHF radar system to map the location, intensity, and velocity of irregularities in electron density in the northern auroral ionosphere. These irregularities, closely associated with the auroral electrojet, can be used to determine electrojet morphology and to obtain a rough idea of the ionospheric electric fields associated with the irregularities. Two VHF radar systems were installed at Siple Station, Antarctica, to determine the morphology of the southern auroral radar echoes and their relationship to other auroral zone phenomena.

Magnetospheric Physics. SEL scientists have determined that a resonance between ion cyclotron waves and magnetically trapped radiation-belt protons is a major process that causes precipitation of these protons into the atmosphere during the recovery phases of large magnetic storms. The existence of these energetic, heavy ions has been detected by the SEL instrument on ATS-6. The presence of heavy ions suggests that both the Earth's ionosphere and the Sun may be sources of radiation-belt particles.

Atmospheric Photochemistry. The Aeronomy Laboratory has developed a technique for measuring the quantity of stratospheric nitrogen peroxide from the ground. This new technique has been used during a global survey with a jet aircraft. Unexpectedly large seasonal variations in the amount of nitrogen peroxide have been found at high latitudes. Automatic monitoring devices are being built, and the first instrument has been installed at Point Barrow, Alaska.

In a joint NOAA/NBS program, NBS developed techniques to detect, measure, and study the rotational spectra of atmospheric free radicals. These techniques are being used to study chemical reactions between free radicals and different halogenated organic molecules released into the atmosphere from natural and man-made sources. High-resolution electron spectroscopy has been used to measure photoabsorption cross sections of the chlorofluorocarbons in the region of the strongest stratospheric ultraviolet flux. Additional characterization of the molecular energy levels of free radicals derived from potential sources of stratospheric chlorine atoms will provide data on the ultimate fate of these fragments and will indicate means for developing systems for detecting them. A measurement of the rate of reaction between atomic chlorine and ozone has been completed. This is one of the processes in the principal catalytic cycle, during which chlorine from chlorofluorocarbons destroys ozone in the stratosphere. The result indicates a slightly lower rate of reaction than earlier predictions. This work relates closely to the current concern over the role of chlorofluorocarbons as potential destroyers of the ozone balance.

Data Programs

Environmental Data

Satellite Data Service. The Satellite Data Services Branch (SDSB) of the Environmental Data Services (EDS) disseminates environmental and Earth-resources satellite data to users. The Branch also provides photographs collected during Skylab missions. SDSB files contain data starting with the early Tiros series, much of the imagery gathered by Nimbus spacecraft, full-Earth disc photographs from ATS-1 and 3, a myriad of images from the ESSA and NOAA satellites, and both full-disc and sectorized images from SMS-1 and 2. Both visible and infrared data are available. A computer terminal, soon to be installed, will link SDSB to NASA's Landsat data base in Huntsville, Alabama.

Climatic and Environmental Assessment. NOAA, the U.S. Department of Agriculture, and NASA are jointly studying the degree to which computer-assisted analyses of data acquired from archives and satellites can contribute to crop forecasting. This program, the Large Area Crop Inventory Experiment, is designed to find whether use of historical and satellite data can improve the timeliness and accuracy of major crop forecasts. The EDS Center for Climatic and Environmental Assessment is responsible for developing and refining the mathematical models that relate crop yields to weather conditions and for providing processed climatological and meteorological data.

Solar Data

The National Geophysical and Solar-Terrestrial Data Center (NGSDC) of EDS and the World Data Center-A for Solar-Terrestrial Physics are archiving and publishing data from satellites and space probes. Solar proton data are obtained from NOAA-2, 3, and 4 and Pioneer 6, 7, 8, and 9; solar X-ray data from OSO-5 and SMS-1; interplanetary electric and magnetic field data from Pioneer 8 and 9; and solar-wind data from Pioneer 6, 7, 8, and 9. The daily solar-wind speed data are deduced from interplanetary scintillation measurements of several radio sources at three stations of the University of California at San Diego. Solar-geophysical data also include direct observations of the Sun, ground-based optical and radio observations of solar flares, daily maps of solar magnetic fields, and ground-based observations of geomagnetic variations and geophysical cosmic rays. NGSDC also archives auroral data from the U.S. Air Force satellites; more recently, the Center has acquired precipitating electron data from these satellites.

Aeronautical Programs

Use of Sensor Data from Aircraft

Outer Continental Shelf Studies. The NOAA Outer Continental Shelf Environmental Assessment Program is using remote-sensing data to investigate the extent, morphology, growth, and decay of landfast ice, the nature of the pack ice, including the frequency of pressure ridges and leads, coastal morphology and erosion, sediment transport by rivers, and the possibility of detecting walrus, seals, and whales by remote sensing. Geological Survey remote sensing aircraft, equipped with side-looking radar, an infrared scanner, and a mapping camera, are collecting bi-weekly imagery of ice, sediments, currents, and coastal features along the Arctic coast from Cape Lisburne to Demarcation Point on the Canadian border. NASA's U-2 aircraft based at Ames Research Center [illegible] flying along the entire Alaskan coast three times a year to take high-altitude color, infrared, and multispectral imagery.

Safety Services for Aeronautics. The NOAA Wave Propagation Laboratory (WPL) has developed an acoustic Doppler wind-measuring system capable of monitoring potentially hazardous wind shears in the 30-to-600-meter height ranges at airports. After successful tests of the acoustic remote sensing system, WPL researchers are continuing development of the device for eventual operational use by the FAA.

The Aeronomy Laboratory is using its recently developed VHF meteorological radar at Sunset, Colorado, to study winds, waves, and turbulence in the troposphere and stratosphere. This long-wave radar measures the parameters of clear-air turbulence and all components of wind velocity in the troposphere with a minimum velocity resolution of 3.7 centimeters per second and a minimum altitude resolution of 150 meters; similar measurements at lower resolutions are made in the stratosphere. The Atmospheric Physics and Chemistry Laboratory also has developed a water-vapor-sensing infrared radiometer that shows considerable promise in the detection of clear-air turbulence.

Air Traffic Control Systems

The Office of Telecommunications has launched a multi-faceted effort to assist the Federal Aviation Administration to advance the technology of air traffic control communications. This includes efforts to improve microwave radar links and develop equipment for measuring the performance of voice communication systems.

Aeronautical Charts

Increased use of the national airspace and more complex air traffic control regulations and procedures have had a heavy impact on the number and type of aeronautical charts needed for air safety. The National Ocean Survey has developed a helicopter chart for low-altitude use in the Los Angeles area. World Aeronautical Charts covering the Caribbean and Mexico have been updated to meet civil specifications. A Visual Flight Rules Radio Navigation Chart and bound versions of the Instrument Approach Procedures have been developed and will be tested during the coming year.

Landsat images are being used to improve the accuracy of hydrographic data on charts. The positional accuracy of all navigational features and airway data is being certified by the National Geodetic Survey.

V

Energy Research and Development Administration

Introduction

The United States Energy Research and Development Administration (ERDA) has the responsibility to develop nuclear electric-power generators required for the nation's space program. These generators have made possible many of the past major United States accomplishments in lunar and interplanetary exploration and they will be essential to the future exploration of the solar system. The Apollo lunar surface and the Pioneer-Jupiter missions are notable examples of nuclear electric power as a critical element of the success of space programs.

This past year, NASA successfully launched the Viking mission, which will make the first exploration of the surface of Mars. Pioneer 10 is now heading toward escape from the solar system and Pioneer 11, having swung around the planet Jupiter, headed on the first journey to Saturn and is expected to fly by the planet in 1979. These missions are possible only through the use of nuclear electric power. In the next two years, nuclear electric power will also make possible the testing of defense satellites where compact and reliable power is a principal determining factor in mission viability. Additional highly sophisticated missions are anticipated in the 1980s and higher performance, lower cost technology is being pursued to ensure readiness for the increased performance demands of these missions.

In each of these applications, the unique characteristic of nuclear energy to operate for long periods without relying on energy from the Sun, along with related attributes such as small size and low weight, has led to the development and use of nuclear power sources. These characteristics will make possible the exploration of the outer planets. Without nuclear power, exploration of these planets cannot take place, as solar power is inadequate at such distances from the Sun. Likewise, nuclear power sources will make possible and economically practical many missions in Earth orbit that need large amounts of electrical power generated by a source of minimum size and with maximum freedom from any Sun-orientation restrictions—i.e., need for a satellite to be continuously positioned so its solar panels receive energy from the Sun.

Specifically, the U.S. has launched sixteen spacecraft powered totally or in part with nuclear power and four more are scheduled for launch during the next two years.

During 1975, the generators required for the Viking and Lincoln Experimental Satellite missions were fabricated and delivered to NASA and the DOD, respectively. Progress was also made on the development and fabrication of the generators for the Mariner Jupiter/Saturn mission and on the technology for more sophisticated applications.

Viking Mars Lander

On August 20 and September 9, 1975, NASA successfully launched the Viking 1 and 2 spacecraft with the goal of traveling to Mars, orbiting the planet, and descending for a soft landing on the Martian surface. Each lander vehicle will be powered by two Pioneer-type isotopically fueled thermoelectric generators, each weighing 14 kilograms. The thermoelectric elements of each generator continuously convert the heat from the spontaneous decay of the radioisotope fuel into electrical power at an efficiency of 5.2 percent. Each generator will provide a minimum of 35 watts—or a total of 70 watts—after 90 days on the Martian surface. The ability of these isotopically fueled generators to operate in the harsh environment postulated for the surface of Mars will enable the extended operation of scientific experiments aimed at understanding the composition and history of our closest planetary neighbor. A major goal is to try to answer questions concerning the presence of life on the planet.

The modified Pioneer-type generators were developed by the ERDA laboratory and industrial contractors organizations. During the year, the four flight generators and one spare were fabricated, tested, and delivered to NASA.

Lincoln Experimental Satellite (LES)

As part of its program to develop a survivable defense communications network, DOD will launch in March 1976 two experimental satellites powered by a new, improved generation of radioisotope-fueled thermoelectric generators, the multi-hundred watt (MHW) generators. These satellites, designated LES-8 and LES-9, will each be powered by two nuclear-powered generators. Each generator will weigh 38 kilograms and provide a minimum of 125 watts, or a total of 250 watts, after five years. The MHW generators are designed for longer life, increased total power, and more power per pound than the generators used on the Pioneer and Viking missions.

Fabrication of the flight hardware was completed during the year for all four flight generators and the spare. All generators were acceptance-tested prior to delivery to the DOD.

Mariner Jupiter/Saturn

The next major program to extend man's exploration out into the solar system will involve launching two Mariner spacecraft in the late summer of 1977 to fly past the planets Jupiter and Saturn. These spacecraft will be relatively sophisticated in comparison to the Pioneer 10 and 11 spacecraft and will enable scientists to gain a much more complete understanding of the atmospheres, surface features, and physical properties of these two large planets.

Each spacecraft will be powered by three nuclear-powered generators providing a minimum of 385 watts when the spacecraft reaches Saturn, approximately four years after launch. The generators required for this mission are a modified version of the MHW design used for LES. Modifications were required to reduce weight and improve entry protection. The 1975 effort was directed toward incorporating these design modifications and fabricating test and flight hardware. Design activities were also completed for the one-half watt radioisotope heaters required to supply heat to the spacecraft instruments during the four-year journey to the outer planets.

Generator Technology

Projected missions of the 1980s will impose increased performance requirements on the nuclear power sources. Weight and overall system unit cost will become extremely important, particularly on repetitive DOD missions. Also, power levels on several missions are anticipated to increase into the low kilowatt range where dynamic conversion systems (turbines, rotors) rather than static (no moving parts) systems are most applicable. Current emphasis is directed toward the selenide thermoelectric materials for the lower power static systems and toward the Brayton or Organic Rankine cycles for the higher power dynamic systems. The selenide thermoelectric materials, and fabrication of a one-kilowatt, 20 percent efficient, dynamic conversion system, will raise system efficiency to 11 percent, double that of the current static conversion system. These improvements will support DOD and NASA requirements for the improved nuclear power systems necessary for national security and the exploration of space.

In 1975, a 20-watt selenide thermocouple module was designed, fabricated, and tested, and demonstrated 8 percent conversion efficiency. Related efforts were conducted on a heat source that would be compatible with this selenide module. Two competing dynamic power system programs, the Brayton and Organic Rankine, were initiated in 1975. Effort included design studies, materials development, and component testing, directed toward the fabrication and testing of ground demonstration systems by 1978.

VI Department of the Interior

Introduction

The Department of the Interior's goal in the field of aeronautics and space is to use aircraft and spacecraft, and the related technology, to improve the efficiency and capability of the department to manage the nation's public lands and natural resources. The department has used a variety of aircraft for many years in its daily operations, for transportation in remote areas, for transmission line surveys, for acquisition of aerial photography, and for fire suppression. Remote sensing is recognized as a valuable additional tool in investigation, planning, development, and management. Incorporation of remotely sensed data into operational programs is just beginning, and its assessment throughout the department is the current goal. The degree to which this has been accomplished in 1975 is reflected in this report of bureau and office activities.

Space

Earth Resources Observation Systems

The purpose of the Interior Department's Earth Resources Observation Systems (EROS) Program is to develop, demonstrate, and encourage applications of remote-sensing data acquired from aircraft and spacecraft which are relevant to functional responsibilities of the department. The primary areas of activity within the EROS Program are: 1) applications demonstration and research, 2) user assistance and training, and 3) data reproduction and dissemination.

A major element of the program is the EROS Data Center (EDC) at Sioux Falls, South Dakota. Data archived at the center total approximately 6,000,000 images, including over 600,000 frames of Landsat imagery; Landsat electronic data in the form of computer-compatible tapes; 40,000 frames of Skylab, Apollo, and Gemini data; more than 1,800,000 frames of data from the National Aeronautics and Space Administration (NASA) research aircraft program; and more than 3,600,000 frames of Department of the Interior aerial mapping photography.

To facilitate regional applications, the EROS Program operates eight Applications Assistance Facilities where the public may view microfilm copies of imagery available from EDC and may receive assistance in searching and ordering data via computer terminal link to the central computer complex at EDC. These facilities also offer assistance in techniques of applying the data to resource problems. Facilities are currently established in Menlo Park, California; Phoenix, Arizona; Denver, Colorado; Reston, Virginia; Bay St. Louis, Mississippi; Ft. Clayton, Canal Zone; Fairbanks, Alaska; and at EDC in Sioux Falls, South Dakota. In addition to these offices, 10 Data Reference Files have been established throughout the United States to maintain microfilm copies of the most used data and to provide assistance to the visitor in reviewing and ordering data.

Applications Demonstration and Research. The objective of this activity is to demonstrate and document applications of remote sensing to significant resource and environmental problems, with emphasis on the utility of NASA and National Oceanic and Atmospheric Administration (NOAA) satellite data. Results to date indicate that remote sensing is a potentially useful tool for resource and environmental problem solving.

To provide a basis for assessing the cost and potential contribution of an Earth-resources satellite, the Interior Department's Geological Survey, in cooperation with other interested Federal agencies, conducted a study to determine the potential economic, social, and environmental benefits to accrue from an operational system. The study was performed under contract to the Earth Satellite Corporation with Booz-Allen Applied Research as subcontractor.

Principal emphasis was placed on a benefit-cost analysis of three alternative systems postulated for the 10-year period 1977–1986—an aircraft alternative, a one-satellite alternative, and a two-satellite alternative. The study shows that benefit-cost ratios range from 0.7 to 2.0 for the high-altitude aircraft system; 0.4 to 1.1 for the one-satellite system; and 0.6 to 1.9 for the two-satellite system. The environmental, social, cultural, and educational benefits may be large, but, generally, are not subject to quantification and economic analysis. The costs of aircraft-collected data for applications not requiring repetitive coverage are approximately equivalent to satellite data, but where repetition is required, duplicating the frequency of satellite data raises aircraft costs far above satellite costs. On the other hand, aircraft remote sensing produces data of substantially higher quality.

In keeping with standard benefit-cost analysis techniques, certain constraints governed the assignment of benefits: 1) technological improvements planned for future experimental satellites will substantially increases costs and could provide significant additional benefits, which were not considered in this study; 2) benefits were restricted to the United States, thereby excluding applications associated with benefits to U.S. industry and Federal government operations in other countries; 3) quantifiable potential benefits that may be derived from new types of information tend to be reduced in value because appropriate changes in management and related substantial investment costs needed to gain these benefits cannot be documented at this time; and 4) benefits from the aircraft alternative were assumed to be the same as those from satellite-quality data, although aircraft data would be of much higher value.

User Assistance and Training. The objective of this activity is to provide assistance and training in methods of remote-sensing data analysis and feature extraction to resource managers, both domestic and foreign. Recognition of the utility of remote sensing has led to an increasing demand for assistance and training by interested users. The number of users requesting assistance increased twofold in 1975, and is expected to double again in 1976.

During 1975, 25 workshops of 3- to 4-day duration were conducted for resource managers from various Federal and state agencies. Personnel trained included representatives from the Bureaus of Land Management, Reclamation, and Indian Affairs, and the Fish and Wildlife Service of the Department of the Interior; the Soil Conservation Service, Statistical Reporting Service, Forest Service, and Animal Plant Health Inspection Service of the Department of Agriculture; the South Dakota State Planning Commission, North Dakota State Water Commission, and the Pacific Northwest Regional Commission.

Two courses for foreign nationals of four weeks in length stressing the fundamentals of remote sensing were held at the EROS Data Center in 1975. Fifty individuals from over 30 foreign countries attended these courses. In addition, the EROS Program and Inter-American Geodetic Survey sponsored a one-week workshop in June 1975, at Fort Clayton, Canal Zone, for 30 Latin Americans interested in the use of Landsat data collection platforms and relay capability for monitoring remote regions.

Data Production and Dissemination. The objective of this activity is to distribute reproductions, including photographic copies and magnetic computer tapes, to domestic and foreign users at prices commensurate with cost of labor and materials. A second objective is to streamline and upgrade operations and facilities to improve remote-sensing data quality, ensure compatibility with long-range plans of other Federal agencies, and decrease time between data acquisition and availability to users.

The demand for reproduction of data archived at EDC continues to increase both in number of frames and dollar value. Data sales and training services totalled $1,600,000 in FY 1975, and are projected to be $2,600,000 in FY 1976. The operating and capital costs of the EDC were $5,800,000 in 1975 and are projected to be $8,300,000 in 1976. Approximately 58 percent of the dollar value for products at the center is for Landsat data. The customer profile for purchase of all data shows that private industry is the largest single purchaser with 30 percent of the total dollar value, followed by agencies of the Federal government with 24 percent. Academic and educational institutions account for 16 percent of data sales, while foreign customers comprise 12 percent. Individuals, state, and local government agencies account for the remainder.

Discussions with resource managers interested in the potential use of experimental Landsat data have indicated that at least two improvements are desirable in the current system: 1) more timely data to aid in making time-critical decisions, and 2) better quality data, both in contrast and spatial resolution, with more flexible formats. The EROS Program is cooperating with NASA and other interested agencies to supply satellite imagery and electronic products in the shortest possible time and in formats users request, consistent with the fact that this continues to be an experimental rather than operational program.

Operational Uses of Space Data

Waterfowl Forecasting. In 1975 the Fish and Wildlife Service, for the first time, used satellite imagery in the preparation of its annual Status of Waterfowl and Fall Flight Forecast, a management document for developing annual waterfowl harvesting regulations in the United States. Forecasts of Arctic geese population—largely dependent on the timely disappearance of snow, ice, and melt water from traditional nesting areas—were originally made from satellite imagery interpretations. Biologists of the Canadian Wildlife Service and the U.S. Fish and Wildlife Service jointly forecasted an optimistic outlook, which was supported later by reports from ground crews. Two satellite systems provided imagery useful for monitoring the Arctic breakup: the Very High Resolution Radiometer on Tiros, and the Multispectral Scanner on Landsat. Landsat imagery was received as quick-look ERTSFICHE cards from a Canadian vendor. Tiros imagery is available routinely from NOAA within six days of satellite acquisition. Satellite imagery is expected to become an increasingly useful management tool as data accumulate from satellites and ground studies, enabling identification of years and areas of probable catastrophic nesting failure in the Arctic.

Natural Resource Information System. The Bureau of Indian Affairs is coordinating an investigation by the State of Washington and the Northwest Indian Tribes into the reliability of automated interpretations of original Landsat digital data dealing with forested lands. Forest cover has been classified by species composition (alder, Douglas-fir, hemlock, and cedar), burned areas, size, and age, including forest recovery. The bureau plans to use the results of this investigation, in concert with available resource data being digitized to their new orthophoto base maps, for continued development of the Natural Resource Information System (NRIS) for monitoring purposes. The Colville Tribe is digitizing landforms, hydrology, ownership, soil types, rainfall, roads, and land-use graphics to create a comprehensive data base for incorporation into NRIS for later automated monitoring. The NRIS manipulates digital data or digitized graphics derived from satellite, aircraft, and ground data, using a polygon approach. The tribe will also perform planning analysis with the system to determine alternate uses, such as reforestation as compared to farm units, type of agricultural uses, and recreation.

The National Park Service is setting up a Resources Basic Inventory (RBI) Pilot Program for park planning and management, drawing on the NRIS developed for the Department of the Interior. The RBI is a collection of physical, biological, and socio-economic data, generally in map format, on a national park. After digitization and conversion into a digital format, the data base can be manipulated as in the NRIS. Additionally, the RBI makes use of a land-use planning system developed by Harvard University and modified by Pennsylvania State University. In the system, each physical, biological, or other attribute is given a score on its suitability to support a given land use. By summing the scores of all attributes, the areas best suited for that particular use can be identified. To date RBIs have been developed for the Great Smoky Mountains National Park, Delaware Water Gap National Recreation Area, and J. D. Rockefeller Memorial Parkway.

The National Park Service is using Landsat digital tapes in an interactive multispectral image analysis system for land classification of Canyonlands, Arches, and Capitol Reef National Parks, and Natural Bridges National Monument. The computer-derived classifications will be added to RBIs for these areas.

Mapping. The U.S. Geological Survey (USGS) is preparing maps from Landsat imagery and Skylab photography for public sale. A satellite image map at 1:500,000 scale of the State of Georgia; ten 1:500,000-scale, single-image maps covering portions of the State of Florida, using data previously prepared for the Landsat image map of the state; satellite image maps of coal-rich areas along the Powder River in Wyoming and Montana; the Hartford 1° x 2°, 1:250,000-scale quadrangle covering most of Connecticut; a 1:100,000-scale satellite image of Hartford and vicinity; and a 1:125,000-scale mosaic of the State of Connecticut have been completed this year. In addition, seven Landsat index maps showing available worldwide coverage by cloud-cover criterion have been printed in quantity for free distribution.

Planetary Exploration. The USGS continued to support planetary exploration. New lunar mapping includes: air-brushed maps of the near and far side of the Moon at 1:7,500,000; preliminary maps derived from digital processing of altimetry, magnetic, gravity, X-ray, and gamma-ray data from Apollo 15, 16, and 17; and preliminary maps color-combining Apollo data with telescopic albedo and other data. Mars mapping at 1:5,000,000 continues, with 10 geologic maps completed. Ten shaded-relief maps of Mercury have been compiled and geologic mapping has started.

Communications in the Trust Territory. The Department of the Interior has supported the PEACESAT (Pan Pacific Education and Communication Experiments by Satellite) Project, a user of the NASA ATS-1, directed from the University of Hawaii. The PEACESAT network has locally owned and operated ground terminals in several locations including Saipan, headquarters for the Trust Territory of the Pacific Islands. In addition to providing satellite communication experimentation and demonstration primarily in the areas of health, education, and community activities, PEACESAT has also been used to transmit to Saipan the annual U.N. Trusteeship Council meetings on the administration of the Trust Territory.

Research on Application of Remote Sensing from Space

Geologic Studies. The USGS takes advantage of the new perspective and temporal and repetitive nature of data from satellites to speed and improve its research efforts. Major advances were made in computerized manipulation of data from Landsat, Skylab, and Nimbus. A method of making Landsat stereopairs has been perfected using Defense Mapping Agency digital contour information. A computer-compiled mosaic of the State of Nevada in simulated natural color was completed. Computer-enhanced Landsat images were used in the detection of altered ground in a Wyoming uranium area and in Sonora, Mexico, to detect lines of geologic structure not previously mapped and apparently associated with mineral deposits in Mexico and Brazil; they were also used to aid in rapidly mapping large areas of difficult access as part of the Alaska Mineral Resource Assessment Program. New computer programs for analysis and display of linear structure elements were used to show the presence of many unmapped structural lines in the Mississippi Embayment, including some which coincide with active seismic zones. High-frequency enhancement of Landsat imagery was used in seismic risk and structure studies in the southeastern United States where dense vegetation normally makes such analysis difficult. Data Collection Platforms were installed on Mount Baker, Washington, to permit monitoring of the increasing activity of that volcano through satellite relay. Analysis of satellite magnetic data is continuing with reduction of data for the Bangui (Africa) anomaly to common elevations to facilitate geologic interpretation.

Geodetic and Mapping Studies. A continuation of the successful Landsat image control experiments using mirror flashes to identify control points on Landsat images is being conducted in Antarctica by the USGS to pinpoint control positions derived from geoceivers (geodetic positioning devices). Application to ice movement studies is also under investigation.

The Space Oblique Mercator (SOM) has been defined by the USGS as the map projection for Landsat imagery and the equations are being derived by contract with DBA Systems, Inc., to relate the SOM plane coordinates to the figures of the Earth in terms of geographic coordinates. This is an essential step for automation of the Landsat mapping system.

A study conducted by Mead Technology Laboratories under contract to USGS has demonstrated that some improvement can be effected in the resolution of Landsat imagery by digitally combining successive images of the same scene. Another study is being conducted to investigate the relationship of tonal scale and resolution in optimizing equipment, materials, and techniques to enable large distribution in photo form. This is aimed at development of an image map which meets considerations of costs, time, and consumer acceptance.

Land-Use Analysis and Mapping. Demonstrations of the utility of data derived from aerial photography, Landsat, and other sources for the compilation, mapping, and graphic display of land-use/land-cover data resulted in 14 research reports covering studies undertaken as part of the Central Atlantic Regional Ecological Test Site Project. Some of the topics included were: land-use perspective, land-use analysis, land-use information and air quality planning, and user evaluation. In conjunction with staff at Purdue University Laboratory for Applications of Remote Sensing, USGS personnel used Landsat digital data to: 1) complete demonstrations of land-use/land-cover change detection over such diverse urban test areas as San Francisco; Washington, D.C.; and Phoenix; 2) develop spatial analysis techniques to supplement the spectral analysis techniques primarily used for monitoring the location and extent of land-use/land-cover changes; and 3) demonstrate possible opportunities for use of Landsat digital data in supporting the compilation of selected land use classification Level II categories, such as forested wetlands; deciduous, evergreen, and mixed forest land; and the delineation of pemanent ice and snow in Alaska.

Remote-sensor data are also helping solve problems arising from interactions of land use practices and environmental factors—for example, analysis of the environmental impact of phosphate mining in Idaho.

Hydrologic Studies. The USGS has used Landsat data to study sediment plumes, circulation dynamics, and Arctic ice dynamics, and to delineate wetlands. Skylab data have been used to analyze the hydrologic system of the Green Swamp, Florida, and to identify fracture-zone lineaments that are potentially high-yield sources of ground water in central Tennessee.

A research project on a strip mine area of Tennessee demonstrated that data from the ground, air, and space could be digitized and made compatible to a single coordinate system, thus establishing a common data base for hydrologic analysis by computer. The project also demonstrated the potential utility of repetitive digital Landsat data for monitoring strip mine change routinely.

The relationship between land-cover type and streamflow characteristics is being studied by USGS in cooperation with NASA, using Landsat data for land-cover-type classification. Statistical techniques were used to analyze predictive estimates of streamflow characteristics with and without four variables defined from Landsat data. In general the streamflow estimates improved with the inclusion of information obtained from the Landsat data.

The Geological Survey has continued to field-test and evaluate an experimental satellite Data Collection System for hydrologic data. Data from about 100 USGS gaging stations are now being relayed from field platforms by Landsat to NASA receiving stations and routed into the Survey's computer system. The data are then processed and made available in near real time via computer terminal connections to field offices. The performance has been excellent but the system is more costly than the present widely used stations that have manual collection. A similar program is being studied in cooperation with NOAA to transmit data via the Geostationary Operational Environmental Satellite (GOES) relay system.

Water Management Studies. The Bureau of Reclamation is actively engaged in developing staff expertise and competence to plan and implement programs for logical and timely incorporation of remote-sensing data in bureau operations. In June 1975, a Remote Sensing and Engineering Physics Section was established at the bureau's Engineering and Research (E&R) Center in Denver, Colorado, to centralize the applications research and develop remote-sensing technology to operational use.

A major effort is under way to develop in-house capability for computer-assisted image analysis from Landsat computer-compatible tapes. The computer software is being installed and tested at the E&R Center under contract. The program also offers the opportunity for training government personnel in use of the system for natural and human resources inventory and monitoring.

In a weather modification program in Montana, the Bureau of Reclamation is using Data Collection Platforms to monitor hydrometeorological parameters, and cloud photographs collected by SMS GOES weather satellite in near real time to study the associated cloud physics. The data are collected and analyzed at the E&R Center where the necessary computer facilities and an image reproducer are in operation. Specially equipped aircraft are used in this program for cloud seeding, data collection, and data relay with ground-base weather radar stations.

The Bureau of Reclamation, Bonneville Power Administration, and the U.S. Geological Survey are cooperating in various NASA-sponsored projects that monitor the extent of mountain snow cover to aid in spring runoff forecasting. Both Landsat and NOAA-2 satellite imagery are being used to interpret the extent of snow cover and rate of depletion, based in part on snowline mapping. Supplemental oblique aerial photography of snowpack is being acquired by the Bureau of Reclamation in its study area in western Colorado.

Aeronautics

Operational Uses of Aerial Data

The USGS utilized aircraft to acquire photographic, other remote sensor, and geophysical data to better perform its mission of geological and geophysical investigations. Airborne sensors were used for aeromagnetic, gravity, radioactivity, microwave, thermal, and geochemical surveys. Contract aircraft logged over 100,000 traverse miles for aeromagnetic mapping. More than half, or 58,000 traverse miles, of these surveys also obtained aeroradioactivity data. A high sensitivity aeromagnetic survey of the Pacific continental shelf is also being made. Almost 38,000 traverse miles will be flown. The objective is to assess the economic potential of the continental margin, especially for petroleum, and also to obtain new knowledge of its geologic structure and tectonic relationships. Other airborne sensors, used singly or in combination, for USGS activities included cameras (for conventional aerial, high-altitude, and multiband photography), thermal infrared scanners, and infrared and microwave radiometers.

In 1975, USGS contracted for more coverage by aerial photography than ever before—473,000 square miles for the national mapping program, 21 percent more than in 1974. More than 81 percent consists of high-altitude, quad-centered photographs for support of orthophotoquad production as well as for aerotriangulation and other photogrammetric applications.

Land-use/land-cover maps and data for 400,000 square miles of the U.S. were compiled under the USGS Land Use Data and Analysis (LUDA) Program, and are being prepared for distribution. The LUDA Program was initiated to provide systematic and comprehensive mapping and compilation of land-use and land-cover data on a nationwide basis. This program employs aerial photography and other sources in compiling land-use/land-cover maps and in developing a computer-stored statistical data base which is incorporated into a geographic information system for use in solving problems associated with land-resource use. Supplemental data accompanying the land-use/land-cover maps are Federal land ownership, river basins and subbasins, counties, and census county subdivisions. Large-scale (1:24,000 and 1:100,000) demonstration land-use/land-cover maps of the Atlanta, Georgia, metropolitan region have been prepared as an experiment to show the relation of the 1:250,000-scale land-use/land-cover mapping to the more detailed large-scale needs for land-use/land-cover mapping.

In the regulation of both onshore and offshore oil and gas operations, the USGS uses aircraft, when they best serve the need, for pollution detection, for overseeing containment and cleanup, for on-site inspections of oil and gas fields and pipelines, and for environmental inspection of locations prior to drilling.

The Bonneville Power Administration uses aircraft in many of its operations, including inspection and maintenance of transmission lines, line-location investigations, surveying, and construction. High-altitude vertical photography and color-aerial photography are used for regional environmental analyses preliminary to facility site selection and for impact evaluations. Low-altitude photography is used to aid in determining locations and size of hydraulic bank storage. With unique methods, Bonneville also performs aerotriangulation and photogrammetric mapping for the U.S. Fish and Wildlife Service.

The Bureau of Indian Affairs agreements with NASA and the USGS to obtain high-altitude photography over all Indian reservations continued in effect, with 85 percent of the photography acquired. The orthophoto base mapping, for which the photography is used, is now 20 percent complete.

The Bureau of Land Management's Division of Cadastral Survey in Alaska has adapted a military-designed inertial guidance system to a helicopter. With it the survey crews have increased their corner monumentation by a magnitude of two to three. Color-infrared aerial photography, flown at high altitudes, has been acquired over large areas of bureau lands to prepare environmental impact statements and baseline inventories.

In 1975, HRB-Singer, Inc., under contract to the Bureau of Mines, completed an inventory of mining activity in the anthracite region of Pennsylvania. Flights had been made in 1974 to acquire aerial photography and thermal-infrared imagery of the entire region. With this imagery and other data, five reports were prepared. Two of these are updated compendia on mine fires and refuse-bank fires. These are used by bureau staff to locate and monitor such fires and to plan control activities. Another volume reports on research in thermal sensing of surface and ground-water discharges from underground mines. The encouraging results should be of use both in pollution control and in controlling water levels in abandoned coal mines. The fourth report is an atlas of remaining strippable coal lands in the region. Aerial data were combined with land-use data and geologic and mine maps to produce this much needed inventory of such lands. The fifth report is an atlas of all mining activity in the region, depicting strip mined areas, refuse piles, fires in abandoned mines and refuse piles, impoundments and other water bodies, and processing plants. This large volume is the first known atlas in which thermal sensing served an equally integral purpose with aerial photography.

Thermal-infrared imagery was used by the Bureau of Reclamation to identify thermal hot springs that contribute mineral salts to the Colorado River. Thermal imagery, along with high-altitude aerial photography, was also used in a study of the geothermal energy potential of Honey Lake Valley near Susanville, California. Multispectral and color-infrared photographs were used to detect evidence of canal seepage on the Uinta Basin Project in Utah.

The National Park Service has used low-altitude mapping photography in a land-use planning study done in cooperation with the town of Springdale, Utah, outside Zion National Park. Medium- and high-altitude NASA photography has also been used for a variety of resource management studies, such as visitor impact on back-country areas, burn mapping, and vegetation and geologic mapping in such diverse parks as Olympic, Grand Teton, Redwoods, Kings Mountain, Lava Beds National Monument, Pictured Rocks National Lakeshore, and Gulf Islands National Seashore. Several forms of NASA aerial photography were used to find a technique for early detection of Dutch elm disease in the National Capitol Park area. NASA high-altitude photography was also employed by the Harpers Ferry Center to construct a large-scale interpretive display for use in a visitor center.

Research Using Aerial Data

Mineral and Geothermal Prospecting. The USGS continued to apply the interdisciplinary approach for developing and improving remote-sensing techniques by identifying the parameters by which rocks, minerals, soil, and moisture can be remotely discriminated and by developing models and methods to analyze and display remote-sensor data. Modelling of thermal characteristics of geologic materials was refined in an effort to optimize the detectability of geothermal prospects from aerial infrared surveys. A thermal-inertia map was produced from aircraft data to delineate potential uranium-host channel conglomerates in south Texas. Temperature anomalies observed in images of the Mt. Baker volcano, Washington, provided evidence that subglacial heating is probably triggering the avalanches that are a serious risk in the area. The microwave, thermal emission characteristics of layered, moist, and frozen soils are being studied both theoretically and experimentally. These investigations have produced new airborne techniques for detecting geothermal, structural, and soil anomalies, and have yielded a better understanding of the spectral radiobrightnesses of the Moon and the planets. Reflectance and thermal surveys were made of a proposed wilderness area in Arizona to speed the geologic evaluation and to define possible mineralized zones. Preliminary statistical analysis of aerial gamma-ray spectrometry data for a uranium area in south Texas suggested that automated mapping of the data can improve existing geologic maps and that radio-activity anomalies may overlie some oil and gas deposits. Luminescent-intensity data obtained by a Fraunhofer Line Discriminator operating from a helicopter were used to identify papermill and phosphate processing effluents and sewage outfalls in tests made in cooperation with the Environmental Protection Agency.

Wetlands Mapping. Remotely sensed data are being used by the USGS in several departmental and interagency research projects on wetlands hydrology, classification, delineation, and mapping. The Survey is assisting the U.S. Fish and Wildlife Service in developing a wetlands classification system in preparation for the upcoming National Wetlands Inventory. The Survey is also cooperating with the Tennessee Valley Authority to develop a wetland classification system that identifies and maps Tennessee wetlands and to study the dynamics of the hydrologic system in relation to changes and species succession. In the Great Dismal Swamp, the USGS, U.S. Fish and Wildlife Service, and NASA are mapping wetland vegetation, analyzing vegetative succession and habitat diversity, and studying wetland hydrology. The Survey is also experimenting with the use of high-altitude color-infrared photography to improve the methodology for mapping inland wetlands on the standard USGS 1:24,000-scale quadrangle series.

Ice Studies. The USGS is contributing aircraft data on the geophysics of floating ice in the Arctic Ocean to two international programs concerned with floating ice: the Arctic Ice Dynamics Joint Experiment, which is studying the dynamics and thermodynamics of sea ice, and the Polar Experiment which is studying the relationship of polar ice to climatic variations and trends.

Water Resources. The Office of Water Research and Technology is continuing support of research using remote sensing from aerial platforms to identify areas of high ground-water potential, to determine water quality and trends of lake systems, to measure snow depth and water equivalent volume, and water movement and distribution in subsoils. New research projects include: in Nevada, development of a watershed runoff-prediction model based on satellite data; in Nebraska, use of infrared thermometry to obtain ground and crop temperature data to develop a resistance model for estimating evapotranspiration rates over large areas. Studies are also underway in cooperation with NASA to develop a reliable wash-water recycle system for use on long-duration spacecraft missions.

International Activities

The USGS conducts a broad program of international cooperation in the Earth sciences, including technical assistance, joint scientific studies, training, and participation in international commissions. As part of this program, a number of remote-sensing activities related to aeronautics and space were conducted in 1975. These include workshops and seminars, consultation and planning activities, and cooperative remote-sensing projects.

During 1975 USGS personnel conducted or participated in workshops and seminars on the applications of remote sensing to geologic, hydrologic, rangeland, or land-resource appraisal in Australia, Brazil, Mali, Ghana, Somalia, and Thailand. In Thailand the activity included a seminar on behalf of the U.N. Economic and Social Commission for Asia and the Pacific (ESCAP) and a workshop for the U.N. Mekong Committee, including Cambodia, Laos, Thailand, and South Vietnam.

Consultation was provided to Costa Rica on possible use of radar data and Landsat data for cadastral surveys of regions over which cloud cover frustrates aerial photography; to Mexico on the preparation and final composition of the project report on use of Landsat data for land-use mapping; to Iran, Pakistan, and Turkey, through the CENTO Regional Study (Landsat) of Igneous and Tectonic Geology; to the Turkish Government on its National Project on Landsat Applications; and to the ESCAP Coordinating Committee for Joint Prospecting of Mineral Resources in Asian Offshore Areas.

Projects included a CENTO program on remote sensing involving Landsat investigations and the presentation of results by 20 CENTO-country scientists at the Third CENTO Seminar/Workshop on Remote Sensing, at Lahore, Pakistan; a USGS-NASA-Government of Nicaragua cooperative Landsat/DCS experimental project on earthquake monitoring; the Thailand National Remote Sensing project, which includes applications programs in geology, forestry, agriculture, and land use, and the development of a National Remote Sensing Center; and continuation of the project for development and application of remote sensing in the search for copper and other metals in heavily vegetated areas. In that project aerial multiband photography and field geochemical data for sites in Brazil and Thailand have been obtained for analysis in cooperation with those governments.

Cooperative projects with the less developed countries are supported by the Agency for International Development (AID), U.S. Department of State. Those with other countries are sponsored by their governments. The remainder have been funded by the international bodies identified with them and by AID, through payment of expenses of U.S. experts on temporary assignment.

VII Department of Agriculture

Introduction

Responsible for helping establish sound public policies for the use of agricultural, forestry, and rangeland resources, the U.S. Department of Agriculture (USDA) is constantly concerned with improving the long-term benefits of its program. During 1975, USDA continued to develop and employ remote sensing technology and techniques to improve agricultural programs that depend upon the rapid accumulation, analysis, and application of information on condition of crops, pests and pathogens, soils, water, and wildlife.

Remote Sensing Activity

The unique multispectral characteristics of aerospace-acquired data have been recognized as potential means for improving the use of agricultural, forestry, and rangeland resources. Especially, remote sensing could provide greater efficiency in inventorying, protecting, and managing these resources. This year research continued with various remote sensing techniques, often in collaboration with other Federal agencies and various institutions.

Research and Development

One of the most destructive parasitic pests of livestock, especially cattle and sheep but including all warmblooded animals, is the screwworm. The larva or maggot of the screwworm fly consumes the healthy flesh of open untreated wounds. The estimated loss to Southwestern ranchers exceeds $100 million annually. The Animal and Plant Health Inspection Service is cooperating with NASA to develop an operational Screwworm Eradication Data System that would provide a method for estimating variation in screwworm populations caused by weather and various biological phenomena. With up-to-date, wide-area information, releases of male-sterile screwworm flies as a control measure could be made more effective. The screwworm weather model supplies twice-daily temperature data, obtained from the NOAA-4 satellite, in conjunction with moisture data obtained from the National Weather Service crop moisture indices.

In anticipation of the proposed Heat Capacity Mapping Mission, the Agricultural Research Service has submitted two research proposals to NASA. One involves using the anticipated thermal data for large-crop-area freeze damage assessment, planting date advisory, and evapotranspiration studies. The other investigation is to demonstrate the feasibility and to evaluate the reliability of assessing soil moisture over large land areas, using thermal data obtained from a space platform.

The Department, in cooperation with NASA and NOAA, is conducting a Large Area Crop Inventory Experiment (LACIE). The purpose is to determine the feasibility of using computer-analyzed satellite data to improve the accuracy and timeliness of crop forecasts. The experiment will combine crop acreage measurement obtained from Landsat data with meteorological data obtained from NOAA satellites and ground stations, and will relate weather conditions to yield assessment and ultimately to production estimates. LACIE Phase 1, April-October 1975, (1) tested the capability of the LACIE system to estimate wheat acreage for selected segments in the U.S. Great Plains, (2) developed yield models for the U.S. and Canada, (3) identified and evaluated problems, techniques, and procedures, from which (4) subsequent research can be planned. A semi-operational test of the acreage measurement techniques has been conducted over the Great Plains and yield models have been tested semi-operationally within the U.S. Results are being evaluated. LACIE Phase 2 goals, begun in October 1975, are to conduct an operational test of selected wheat acreage, to devise a system for estimating yield and production over the Great Plains and Canada, and to evaluate the results.

Significant Developments

Complete, cloud-free photomaps of the 48 contiguous United States, from Landsat 1 multispectral scanner (MSS) imagery, have been developed by the Soil Conservation Service (SCS) in collaboration with NASA. The maps were compiled and assembled from photo mosaics taken in MSS Band 5 (visible red) and Band 7 (near infrared). The original mosaics were constructed at a scale of 1:1,000,000 and finally reproduced at various scales ranging from 1:10,000,000 (100 kilometers=1 centimeter) to 1:500,000 (5 kilometers=1 centimeter). The photomaps are rendered in two seasonal aspects—summer and winter. The summer season map was compiled from imagery obtained primarily from July through October 1972. The winter aspect was obtained from imagery taken primarily from December 1972 through March 1973. Reproductions of the summer aspect have been available since 1974. Winter aspect reproductions will become available about January 1976. Either seasonal photomap may be obtained as a Band 5 or Band 7 rendition. Government agencies (domestic and foreign), schools and universities, private concerns, and individuals, bought approximately 6000 prints during the past year.

The following significant advances in use of remote sensing technology and techniques were made by the Agricultural Research Service during 1975:

- Use of remotely-acquired soil-surface temperatures in conjunction with routine weather network data to estimate actual evaporation rates through all stages of soil drying.
- Development of an information management system enabling retrieval of Landsat data corresponding to ground-truth samples; this may be used either in locating crop fields for training in discrimination or for evaluating classification results of satellite imagery.
- Development of watershed storm runoff potentials (coefficients), classified by remote sensing measurement from an airborne passive microwave imaging scanner.
- Enhancement of rate and quality of soil mapping by use of aerial color and color infrared photography.
- Rapid detection of fire-ant infestations with remote sensing methods.
- Development of operational systems parameters for analysis of agricultural remote sensing data.

Other Activities

A Remote Sensing Users Requirements Task Force, comprised principally of representatives from eight USDA user agencies, along with additional expertise provided by specialists from NASA and several universities, has cataloged the Department's requirements for Earth-resource data. The task force developed a procedure for analyzing over 3000 resource data requirements and appraised the current status of remote sensing technology to satisfy the requirements. Data requirements are now matched against remote sensing systems that are operational, still in development, or at the research stage. Remote sensing systems that indicate maximum potential for both short- and long-range benefits will be identified in the near future.

Assistance and advice on the feasibility and practical employment of agricultural remote sensing technology were sought by a number of foreign visitors during 1975. In cooperation with the Departments of Commerce and State, briefings were given to representatives from Australia, Bolivia, Germany, Israel, Italy, Japan, Peru, Saudi Arabia, Syria, and Thailand.

VIII National Science Foundation

Introduction

The National Science Foundation is an agency of the Federal government established to advance scientific progress in the United States. The Foundation fulfills this responsibility primarily by sponsoring scientific research, encouraging and supporting improvements in science education, and fostering scientific information exchange. NSF supports research activities related to aeronautics and space sciences in astronomy, atmospheric sciences, engineering, materials research, polar programs, and education activities. NSF also supports National Research Centers, available to visiting scientists to pursue research relevant to space sciences and aeronautics.

Astronomy

General

Photons are the universal currency of the electromagnetic spectrum, coming in energy denominations ranging from low-energy radio waves to visible light waves to high-energy X-rays and gamma rays. For astrophysicists and astronomers photons convey basic information about the structure, energy sources, and life cycles of stars and galaxies. The highly energetic X-rays and gamma rays are of particular interest because they are produced by electrons possessing very high velocities. How these electrons acquire their enormous energies raises intriguing questions about fundamental processes at work in the universe.

X-rays and gamma rays cannot be observed from the Earth's surface because the atmosphere acts as a screen. For this reason astrophysicists send their instruments beyond the Earth's atmosphere by rockets, or suspend them beneath 90-story-tall balloons, to be lofted above 99.7 percent of the Earth's atmosphere. Future experiments flown from the Northern or Southern Hemispheres will give information on black holes, quasars, radio galaxies, and other unidentified X-ray and gamma ray objects.

Kitt Peak National Observatory

Kitt Peak National Observatory—an NSF-supported research center for ground-based optical astronomy in the Northern Hemisphere—today maintains the world's largest concentration of facilities for stellar, solar, and planetary research. Located in the Quinlan Mountains 91 kilometers southwest of Tucson, Arizona, the observatory is the site of the nation's second largest reflecting telescope, the Mayall 4-meter instrument, as well as the largest solar telescope, the 1.5-meter McMath instrument. A planetary program supports studies of all the planets of the solar system. Using spectrographic techniques, telescopes record the light transmission and absorption characteristics of planetary atmospheres. The data are used to develop theoretical atmospheric models.

For a closer look, KPNO staff have designed experiments for the 1973 Mariner Venus/Mercury (MVM) mission and the 1977 Mariner Jupiter/Saturn (MJS) mission. An ultraviolet spectrometer was designed to observe airglow radiations in the spectral range 200 to 1700 angstroms aboard the MVM. Successful observations were obtained during the mid-March 1975 third encounter with Mercury. Analysis of data from previous encounters indicates that the solar system's innermost planet is surrounded by a thin atmosphere consisting in part of helium. Hydrogen, oxygen, carbon, argon, neon, and xenon were also observed.

The KPNO experiment aboard the MJS 1977 spacecraft is designed principally to determine the concentration of the main constituents in the atmospheres of Jupiter, Saturn, and Titan, and also determine the distribution of hydrogen and helium in the interplanetary and interstellar medium.

Daily magnetograms of solar observations conducted with the solar vacuum telescope are provided to NASA. The magnetograms indicate magnetic fields on the Sun and are used by NASA to support its orbiting solar observatory program.

National Radio Astronomy Observatory

Research in astronomy now depends on observing celestial objects and regions in their characteristic emissions throughout the frequency spectrum, whether these be X-rays, visible light, infrared radiation, or radio waves. NRAO, headquartered in

Charlottesville, Virginia, provides large radio telescopes, auxiliary equipment, and support services required for sensitive observations of the radio sky. The principal users of the four NRAO telescopes, three at Green Bank, West Virginia, and one on Kitt Peak near Tucson, Arizona, are visiting radio astronomers and graduate students from throughout the United States. A major new radio telescope, the Very Large Array, is now under construction on the Plains of San Augustin near Socorro, New Mexico.

National Astronomy and Ionosphere Center

The NAIC mission is to provide the scientific community with unique facilities for research in radio and radar astronomy and aeronomy. The primary research instrument is the Arecibo, Puerto Rico, radio/radar telescope that incorporates a 390-meter-diameter spherical reflector and a 545-metric-ton feed platform suspended 115 meters above the reflector and associated transmitters and receivers.

This past year was the first full year of operation of the new S-band (2380 MHz) planetary radar system sponsored by NASA and operating through the Arecibo telescope. In 1975, new observing programs studied the properties of the rings of Saturn and the satellites of Jupiter and prepared detailed topographic maps of the surface of Venus. The maps of the cloud-obscured surface of Venus show terrain detail as small as two kilometers in size.

In addition, the S-band and 430-MHz planetary radar systems were used to make radar observations of the surface of Mars. These studies were conducted in collaboration with the NASA Viking lander scientists. The radar data have provided valuable new information on the constitution, texture, and electrical properties of the material forming the Martian surface.

Atmospheric Sciences

Meteorology

This program investigates the dynamical and physical behavior of the atmosphere by means of field observations, laboratory experiments, and theoretical and numerical analysis. Techniques are being developed for remote sensing of atmospheric motions and of particulate and gaseous species. Over the past several years there has been an expanded program of research on the chemistry of the troposphere and stratosphere.

Solar-Terrestrial Research

In studying the dynamic interaction between the Sun and the Earth, an interdisciplinary approach is required. NSF supports such studies by optical and radio observations of the solar atmosphere, observations of the expanding solar envelope (the solar wind), and measurements of the Earth's magnetosphere and upper atmosphere. Cosmic ray studies provide a common link for all four regions. In 1975 further progress was made in implementing the International Magnetospheric Study. This intensive, cooperative effort in 1976-79 will further our knowledge of the near-Earth environment and the way in which it is influenced by the Sun. Studies will include auroral particle precipitation, geomagnetic perturbations, hydromagnetic wave propagation, plasma physics, and electric fields.

Aeronomy

Aeronomy is concerned with the Earth's high-altitude atmosphere and its interactions with the lower atmosphere and with the space environment. The Foundation supports theoretical, laboratory, and field studies of phenomena that occur in this region, including airglow, aurora, ionospheric dynamics and instabilities, and chemical processes. In addition to the general work, current emphasis is on high-altitude investigations related to the International Magnetospheric Study and on a variety of studies of the chemistry and dynamics of the natural and disturbed stratosphere related to understanding man's impact on this region.

National Center for Atmospheric Research

In cooperation with universities and other organizations, NCAR plans and executes atmospheric research programs. NCAR also develops and operates special research facilities in support of the national atmospheric research effort.

The Tropical Wind, Energy Conversion and Reference Level Experiment (TWERLE), a collaboration between NASA's Goddard Space Flight Center, the University of Wisconsin, and NCAR, has entered its operational phase. The Nimbus 6 satellite, launched in June 1975, is successfully tracking several hundred TWERLE balloons and relaying information to the Nimbus control center. The objectives of the TWERLE experiment are tied to the Global Atmospheric Research Program. Chief objectives are to measure tropical winds at the 150-millibar pressure level and to measure air motions that relate to energy transfer processes in the global atmosphere.

Polar Research Programs

The Foundation continues its support of upper atmosphere investigations in the polar regions. Most measurements made in these regions cannot be made elsewhere.

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Instruments at Thule, Greenland, and McMurdo, Antarctica, recorded cosmic rays penetrating to Earth from opposite directions perpendicular to Earth's orbital plane—a perspective not possible in lower latitudes. Comparison of simultaneous observations from the two locations has revealed puzzling transient differences in cosmic ray intensity—a north/south asymmetry.

Researchers from nine institutions performed extensive investigation of the magnetosphere in June and July at Roberval, Quebec. The site is geomagnetically conjugate to Siple Station, a unique U.S. facility in Antarctica. The 21-kilometer-long, very-low-frequency (VLF) antenna at Siple transmitted in a number of modes, and instruments at Roberval measured the effect on the magnetosphere. Balloons over Roberval at 34-kilometers altitude measured trapped particles precipitated by the VLF emissions and measured VLF and other electric fields. Analysis of the extensive data is in progress.

Engineering

Support related to aeronautics research has been provided for the systematic investigation of transition from laminar to turbulent flow and the effects of external disturbance on transition, as well as stability computations.

Materials Research

Of the numerous NSF-funded activities in materials research, two general areas are of particular significance to aerospace. These involve studies of the mechanical and the electro-optical properties of materials. The development of advanced aerospace vehicles is critically dependent upon high-performance structural materials, be they metals, ceramics, or polymers. Current efforts to better understand these materials include studies of the hydrogen-embrittlement of metals and the use of thermodynamic and phase equilibria data for predicting the properties of complex alloys. Fabrication of polymer fibers having strengths in excess of the best steels, at less than one fifth the density, opens new horizons for organic composites. Moreover, recent research on block and interpenetrating-network polymers suggests that organic composites can be toughened, thereby further improving their usefulness.

Materials research in the solid-state sciences represents a second general area of importance to aeronautical and space technologies. Fundamental investigations of defect formation, diffusion, and impurity effects in metals, insulators, and semiconductors have an obvious bearing on the future development of improved devices.

Education Activities

In fiscal year 1975 the Foundation's Education Directorate supported graduate and postdoctoral training in aeronautics and space sciences, including the support of 24 graduate students in NSF's Graduate Fellowship program. The Faculty Research Participation program helped upgrade the aeronautics and space sciences subject matter background of 26 college and university faculty members.

IX Environmental Protection Agency

Introduction

The critical concern to protect the environment while developing domestic energy resources and new energy technologies has recently led to the creation of a Federal Energy/Environment Research and Development Program, coordinated by the Environmental Protection Agency's Office of Research and Development (EPA/ORD) with seventeen participating Federal agencies. A portion of this effort includes the development and application of aerospace technology through a series of interagency agreements with the National Aeronautics and Space Administration (NASA) and the Tennessee Valley Authority. The major aerospace-related activity is a joint EPA-NASA aerial monitoring study of environmental conditions in the vicinity of energy development sites, such as coal strip mines and mine-mouth power plants in the western United States.

In addition, EPA has in the past year continued its involvement in an advanced monitoring program to solve critical environmental measurement and monitoring problems through the unique capabilities of aerospace-derived technologies. This program has been devoted to (1) the development of aerial monitoring techniques for identifying the sources of pollution, (2) determining pathways by which pollution enters the environment and the extent of its effects, and (3) the development of remote measurement instrumentation. The purpose of this program is to provide cost-effective monitoring technology and advanced technical assistance to EPA offices and regions, as well as to states and local agencies with responsibilities for assessing environmental problems and enforcing laws and regulations.

Energy-Related Environmental Research and Development

Western Energy/Environment Monitoring Study

One major direction of activity being pursued by the Office of Energy, Minerals, and Industry (OEMI/ORD) is the Western Energy/Environment Monitoring Study. This is a multi-year, multi-media baseline monitoring study being carried out by EPA primarily in the Northern Great Plains and Rocky Mountain states. Field coordination of the study is being carried out by EPA's Environmental Monitoring and Support Laboratory (EMSL), Las Vegas, Nevada.

A major purpose is to establish a baseline against which can be measured the impact of energy development on the land. To carry out this aspect of the study, EMSL/Las Vegas is coordinating aircraft collection of infrared and multispectral analyzer data at various energy development sites and correlating such data with corresponding air and water quality monitoring data. Aircraft support is provided both by EMSL/Las Vegas and by NASA. EMSL/Las Vegas has coordinated flights with corresponding ground-truth measurements made by seven Federal and state agencies, including other elements of EPA. This information provides a synoptic overview of the extent, variation, effects and, in some cases, the pathways of pollution from specific sources, as well as a record of land disturbance caused by development. Such parameters as visibility, vegetational stress, sedimentation drainage patterns, thermal pollution, land erosion, and subsidence will be evaluated at various sites. The technology for more refined interpretation of such data will be developed concurrently.

One important feature of this effort is monitoring reclamation of mined lands. In addition to collecting information on the extent of development and ecosystem damage, the EMSL flights over strip mining areas will employ a laser terrain profiler which is capable of rapidly measuring the contours of strip mine excavations and associated reclamation with a resolution of a few inches. This information is valuable in quickly determining whether restoration has been carried out properly. This may have real significance for future regulation of strip mining.

In addition, both present hardware and software techniques and those developed during the project will allow the EPA to establish and man a fully operational energy-related overhead monitoring system by maximum use of its present aircraft capability to supplement remote data acquired by satellite.

Although maximum use would be made of present Landsat capability, Landsat's resolution may not be adequate.

At first the program will concentrate on the development of aerial remote sensor techniques to monitor environmental factors related to coal extraction and rehabilitation. Roughly half of the total effort will be to monitor these activities in the Northern Great Plains, Utah, Colorado, Arizona, and New Mexico. Sites of planned activity and active sites will be included. Environmental impact on surface and near-surface water, soil condition and slopes, subsidence manifestation, vegetation density and speciation, and other rehabilitation aspects will be considered.

Approximately one third of the program will be dedicated to monitoring environmental impact from mine-mouth fossil fuel power plants. Both on-line and planned sites will be monitored. In addition to activity in the Northern Great Plains, sites in Utah, Colorado, New Mexico, Arizona, and Nevada will be observed for specific environmental concerns, such as effects from particulate and sulfur dioxide emissions on surrounding vegetation vigor and density and on synoptic visibility.

Other work will relate to problems associated with oil shale extraction, conversion, and waste site rehabilitation. Monitoring the extent of environmental impact associated with accumulation of spent shale and potential related surface runoff into the drainage system will be considered. Fugitive dust from spent shale may be of concern, depending on the effectiveness of revegetation efforts. Most of the initial coverage will be of undeveloped sites. Monitoring will continue as extraction and rehabilitation proceed.

A smaller effort will be made to develop monitoring techniques applicable to the environmental effects of geothermal development. The probability of high-salinity brines entering the surface and near-surface water is evident. Aerial thermal and other techniques will be investigated for applicability. Sites in California will receive attention first.

The management system for these data is not operational but has been under development. REMIDS (*R*emote *M*icro *I*magery *D*ata *S*ystem) will incorporate coded data cards with a microprint insert of the specific site noting each outfall point. After periodic collection of data for several years, regulatory officials will have a synoptic record against which to evaluate the effects of regional energy development.

Finally, the planned correlation and integration of multimedia data by energy site and as a function of time will establish an evolving "time lapse" overview of western energy development, along with an accurate quantitative environmental data baseline and a record of deviations from that baseline. Then, the environmental aspects of energy development in the West can be evaluated over five years by both national energy and environmental policy makers. The program could be useful earlier to regional and local decision-makers.

The key mechanism now planned for disseminating the scope and details of the study as it evolves is the Western Energy/Environment Monitoring Study Atlas, a compendium of environmental information from major western energy development areas. It will contain photographic map coverage of specific sites, such as individual strip mines, along with a list of relevant air and water baseline data and land monitoring baseline data. It will also contain an evaluation of current environmental conditions in the area and a key for accessing actual data. The document will be published periodically for distribution to key Federal and state officials and to other concerned parties.

In addition, EPA is supporting remote monitoring efforts of the Tennessee Valley Authority (TVA) to determine the extent, intensity, and effects of sulfur dioxide emissions from fossil-fueled electric generating stations. The primary purpose of this effort is the testing, refinement, and development of infrared and multi-spectral scanning techniques for assessing effects chiefly on soybean crops and mixed stands of southern pine and deciduous hardwoods.

Pollutant Emission Research

OEMI, through EPA's Industrial Environmental Research Laboratory, Research Triangle Park, North Carolina, is supporting an interagency agreement with NASA's Jet Propulsion Laboratory (JPL) to study fuel combustion processes with the aim of minimizing nitrogen oxide emissions.

Combustion interactions among multiple burners using natural gas, light fuel oil, and coal are being examined. This effort will be a guide to reducing emissions of nitrogen oxide from larger scale facilities. A catalytic partial oxidation reactor is also being developed, with which EPA researchers can study nitrogen oxide emissions from a variety of low-BTU gases. This will allow EPA to simulate combustion of fuels from a wide range of coal gasification processes.

Remote Measurements of Energy-Related Pollutants and Effects

The Office of Energy, Minerals, and Industry is sponsoring a number of projects aimed at accelerating development of remote measurement instrumentation for energy-related pollutants and their effects. Remote sensing methods, including those using an airborne platform, offer a potentially important contribution to solution of the problem of formation, transformation, and transport of aerosols and fine particulates. This can assist the evaluation of EPA's control strategy on a regional and local basis.

- EMSL/Las Vegas is developing a multi-wavelength Light Detection and Ranging (LIDAR) system for measuring particulate signatures from specific sources and is evaluating a tracer dispersion system for optimizing site selection of sources.
- NASA's Langley Research Center is developing, under an interagency agreement, a tunable infrared differential absorption LIDAR which has the potential for sensitive measurement of several pollutant compounds, including sulfur dioxide.
- NOAA/Boulder is developing a LIDAR for differentiating between stack-produced and naturally occurring aerosols.
- EMSL/Las Vegas is developing a laser fluorosensor system for identifying specific oils on surface water.
- EMSL/Las Vegas is evaluating laser fluorosensors for remote monitoring of vegetational stress.

Advanced Monitoring Program

EPA's Office of Monitoring & Technical Support is identifying EPA's critical monitoring needs and then developing the remote sensing technology that can fulfill the requirements. Through a reorganization of the EPA/ORD, the research and development for remote monitoring in the Agency is conducted at the Environmental Monitoring and Support Laboratory (EMSL) in Las Vegas, Nevada. EMSL/Las Vegas has established a Remote Sensing Directorate to develop, apply, and conduct aerial and ground-based remote monitoring for assessment of environmental quality. The new Division will be the focal point for all advanced monitoring activities in the Agency and will direct and coordinate other remote sensing developments within the Agency.

Non-Energy Uses of Remote Monitoring

Oil Spills. EMSL/Las Vegas has responded to a number of emergency oil spill situations. This included an oil tanker collision on the Delaware River which resulted in fire, explosion, loss of life, and a spill of more than one million gallons of crude oil. The oil spill covered 80 kilometers of shoreline. Aerial overflights directed by personnel of EMSL/Las Vegas provided black and white and color photography. The black and white film was processed promptly in the field to assist immediate clean-up operations. The color film was processed and analyzed at the EMSL/Las Vegas where annotated maps were prepared. This information was provided to Federal personnel directing clean-up operations and was also used for environmental damage assessment.

Ocean Dumping. The Agency, in cooperation with NASA, has been conducting test flights over the New York Bight in a U-2 aircraft to evaluate the NASA coastal-zone color scanner scheduled to be installed on the Nimbus-G satellite. This instrument is being evaluated for monitoring ocean dump sites and transport phenomena.

In another significant remote-monitoring development, an experimental buoy has been installed approximately 60 kilometers southeast of the mouth of Delaware Bay. Deployed by the U.S. Coast Guard, it is one of a group of buoys for gathering environmental data from the waters of the Continental Shelf. This particular buoy, EB-52, supports a cooperative study being made by NOAA and the EPA. The water quality instruments are measuring chlorophyll, conductivity, dissolved oxygen, pH (acidity), temperature, and clarity. The site is located within the Philadelphia municipal sewage-sludge disposal area and is also near an industrial acid disposal site. Data are reported automatically via an HF radio link. The buoy may also be interrogated from shore.

Land Quality and Use. The Agency makes extensive use of land-use mapping acquired through aerial and satellite sensors. The analyzed thematic maps are furnished to the EPA Regional Offices. Some examples of the land-use maps developed for the Region include:

- Detection, location, and extent of duckweed blooms near Birmingham, Alabama, for ecological assessment.
- Location and mapping of oil storage facilities for assessing the effects of possible spills on nearby bodies of water.
- Mapping of all animal feed lots in Elkhorn River Basin, Nebraska, for possible sources of pollution in this drainage basin.
- Evaluation of rehabilitation activities of disturbed areas and status of vegetative species associated with strip-mined areas in the Northern Great Plains.
- Mapping and assessment of urban areas subject to noise effects from air traffic around six metropolitan airports.
- Application of remote sensing to detect and monitor land-fill sites subject to leaching.

Air Pollution and Effects. Several projects have been under way:

- A LIDAR system is being evaluated during the Regional Air Pollution Studies in St. Louis, Missouri. Installed on an aircraft, the instrument is measuring the particulate burdens in the atmosphere and the air-inversion locations and mixing heights.
- Measurements of opacity and particulates are being conducted around smokestack plumes through the use of photographic and LIDAR techniques.
- Vegetation damage resulting from sulfur di-

oxide and dust from coal-fired plants is being assessed through the use of multi-spectral scanning and color IR photography.

Water Pollution and Effects. The several projects include:

- Assessment of environmental impact to North Carolina wetlands as a result of converting land to agricultural use.
- Mapping of thermal discharges from power plants located in tidal waters to assess environmental trends.
- Environmental assessment of flood damage to petroleum facilities as in the case of the Atchafalaya River Basin flood.
- Mapping of actual and potential water pollution sources in northwest Iowa, such as waste-treatment sewage lagoons, sand and gravel pits, construction site runoff, and large auto graveyards.

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National Academy of Sciences
National Academy of Engineering
National Research Council

Introduction

The National Academy of Sciences is a private society of scholars in scientific and engineering research, dedicated to the furtherance of science and its use for the general welfare. Its charter, an Act of Incorporation passed by Congress, calls upon it to serve as an official advisor to the Federal government on any question of science or technology.

The National Academy of Engineering is a parallel organization of engineers that shares with the Academy of Sciences the responsibility for advising the Federal government.

Most of the activities undertaken by the two academies are carried out through the Commissions and the Assemblies of the National Research Council, which draws upon a wide cross-section of the nation's leading scientists and engineers.

Aerospace Science

Space Science Board (SSB)

The Space Science Board was established to provide programmatic and policy advice for the national scientific program in space research. The Board's major effort for 1975 was to update the priorities study of 1974 (see *Opportunities and Choices in Space Science, 1974,* National Academy of Sciences, Washington, D.C., 1974). New scientific discoveries, better definition of proposed missions, and changes in fiscal constraints made this revision necessary.

The disciplinary committees of the SSB (the Committees on Space Astronomy and Astrophysics, Space Physics, Lunar and Planetary Exploration, Space Biology and Medicine, and the Exobiology Panel) were involved in the effort to examine the scientific merits and technological aspects of proposed space science programs. In addition, summer studies defined the status and priorities for research in two areas: (1) Infrared and Submillimeter Astronomy, and (2) Solar Physics.

The Board was also involved in planning for the 19th Plenary Meeting of COSPAR (the Committee on Space Research of the International Council of Scientific Unions). The National Academy of Sciences, as the representative of the United States, will serve as host for the meeting in Philadelphia in June 1976.

Committee on Solar-Terrestrial Research

The Committee on Solar-Terrestrial Research (CSTR) reviews and makes recommendations on the national program in solar-terrestrial physics and, through international bodies, participates in the organization and planning of international research in solar physics, interplanetary medium, planetary atmospheres, and the magnetosphere. In February 1975, the Science Advisor of NSF prepared a *Government-Wide Plan for the International Magnetospheric Study* (IMS) for the Office of Management and Budget. This plan is largely based on major recommendations provided by a joint study by CSTR and the Space Science Board in 1973, and a report by the CSTR Panel on the IMS in 1974. The chief objective of the IMS is to obtain a comprehensive, quantitative understanding of the dynamical processes operating on plasmas in the geomagnetic field. The operational basis of the IMS is an international plan of coordinated observations from spacecraft, ground-based facilities, aircraft, balloons, and research rockets.

Committee on Atmospheric Sciences

The Committee on Atmospheric Sciences, to ensure a balanced national program, examines progress and future needs related to scientific, technical, and national problems and encourages research and development wherever such needs are revealed. The Committee also monitors the manpower needs and educational characteristics of the scientific community in terms of the ability of the United States to carry out programs that have been identified for greater effort and support.

The Committee is now in the final stages of the last of several studies identified for attention in 1970, including: weather modification (1973); climate and climate change (1974); atmospheric chemistry (1975); and severe storms and short-term predictions (in process of completion). Since many of the needed observations for the last three fields must come from an integrated, well functioning system of ground-based, airborne, and satellite sensors, the major agency responsibilities were identified.

Data from satellites on atmospheric temperature, moisture, trace gas, particulate constituents, and solar and terrestrial radiation must be obtained to improve global prediction of climate, atmospheric chemistry, and short-lived severe weather phenomena. In addition, interrogation by remote sensors of land masses, ice masses, and the oceans is important for obtaining observations in difficult terrain and remote regions.

The need for direct application of all current observational techniques and capabilities is being recognized by scientists and by the technical administrators of Federal and state agencies. The use of advanced observational techniques will be greatly enhanced when they are directly coupled to advanced computers that allow theoretical, experimental, and diagnostic studies to be undertaken on our complex physical environment.

Global Atmospheric Research Program

Stemming from resolutions of the United Nations in the early sixties, the Global Atmospheric Research Program (GARP) is being conducted under the joint sponsorship of the International Council on Scientific Unions and the World Meteorological Organization. The principal objective of GARP is to study the physical processes of the atmosphere for better understanding and prediction of the transient behavior of the global atmosphere and the statistical properties of the general circulation that would lead to greater knowledge of the physical basis of climate. The U.S. Committee for the Global Atmospheric Research (USC-GARP), the principal body for defining and developing United States participation, works closely with the principal Federal agencies in the planning and implementation of the programs.

Intensive research and data reduction from major subprograms conducted earlier are presently underway. The GARP Atlantic Tropical Experiment (GATE) was successfully conducted from June to September 1974. Many nations contributed to the program, which employed an unprecedented array of surface, balloon, aircraft, ship, buoy, and satellite observational systems. Geostationary and polar orbiting satellites provided crucial research and operational data.

On a somewhat smaller scale, and under the leadership of Japanese scientists, international participation in the second phase of the Air Mass Transformation Experiment (AMTEX) was carried out in the South China Sea during the late winter of this year. In both the GATE and AMTEX the interaction of various scales of dynamic weather systems was studied with a view to incorporating key processes into numerical models of the general circulation.

These experiments are principal precursors of the First GARP Global Experiment (FGGE), scheduled for 1978-79. This will be a twelve-month period of intensive global observations of the atmosphere and oceans, utilizing the complex array of surface, airborne, satellite, and special observing and measurement systems. Satellites will have a central role in providing a variety of observations, as well as serving as interrogation and data communication platforms. The needed planning and preparation for the U.S. participation in the FGGE is now the primary function of the USC-GARP.

Climatic Impact Committee

The Climatic Impact Committee was established as a multidisciplinary committee in response to a request from the Department of Transportation. The function of the Committee has been to advise interested elements of the Federal government on planning and interpreting results from research programs to assess the climatic impact, and other effects, of high-altitude vehicles, flights of Space Shuttles, and other activities of man that can affect the atmosphere, and in particular the stratospheric portion thereof. The Committee is studying the environmental impact of various chlorinated compounds, including fluorocarbons used as refrigerants and aerosol propellants, through their effect on the Earth's stratospheric ozone layer. A report of the Committee's assessment of the climatic and biological impact of a projected fleet of high-altitude aircraft, *Environmental Impact of Stratospheric Flight,* was released in April 1975.

Geophysics Research Board

The Geophysics Research Board (GRB) was established to effect participation by U.S. scientists in the activities of international geophysical organizations and to stimulate and encourage research in the United States in geophysics and related fields.

In response to numerous suggestions from the scientific community, the GRB and the Space Science Board are jointly sponsoring a study of the uses of balloons for astronomical and geophysical observations. For administrative purposes, the study was organized under GRB.

The study of scientific ballooning will include a review of past scientific achievements, an assessment of the future promise of this technique, and a definition of the equipment and facilities needed to realize the potential of ballooning. The stimulus for the study was a widespread belief among scientists that the balloon's potential for obtaining high-quality scientific data at low cost is far from being fulfilled. The Balloon Study Committee began its work in spring 1975 and should complete its study within one year.

The GRB also sponsors the Committee on Data Interchange and Data Centers. This Committee was established to meet the problems of international exchange of geophysical data through the World Data Centers (WDCs) and to advise the GRB and the Director of WDC-A (the U.S. Center) on policies and effectiveness of the service to the U.S. scientific community of both the WDC-A complex (eight discipline-based subcenters and the Data Center Coordination Office) and other U.S. data centers and services. The Committee is concerned with coordination of these services and their improvement, especially in regard to effective use of the centers, quality control of the data, and services to the scientific community.

Committee on Toxicology

The Committee on Toxicology (TOX) has been engaged in several aeronautics and space-related activities:

- The Committee is waiting to evaluate the results of a current NASA contract relating to the toxic effects of mercury from the ion engine, as mentioned in last year's report.
- As a result of last year's study of the toxic aspects of fires in aircraft lavatories, the Committee is undertaking a long-term study of fire toxicology.
- References on the toxicology of hydrazine propellants were provided for use in waste-disposal problems.
- References were provided on the toxic effects of hydrogen chloride for use in problems from propellant exhausts.

Space Applications

Space Applications Board

The Space Applications Board (SAB) advises the government on how the national space capabilities may be used to benefit mankind.

In 1974 the Board organized a study to review progress in the practical applications of space systems and to solicit user needs that might be met by such systems. In the study, potential users drawn from Federal, state, and local governments, business, and industry served on panels in the fields of weather and climate, uses of communications, land use, agricultural resources, water resources, extractable resources, environmental quality, maritime activities, and materials processing in space. During 1975, the Board has reviewed the work of the study panels, evaluated their findings, and issued a report (see *Practical Applications of Space Systems*, National Research Council, 1975) which includes significant recommendations based on the work of the panels, as well as conclusions and recommendations arrived at by considering the work of the study as a whole.

The Board concluded that present institutional arrangements are not adequate to encourage future applications of space technology. Since no institutional mechanism exists that permits the large body of potential users to express their needs and to have a voice in the definition of new systems, the Board recommended that Congress establish a national space applications council to direct policies affecting non-military space applications; set priorities for meeting user needs; provide for exchanges between users and providers of space technology; and encourage non-Federal investment in the application of space systems. The report calls for the council to operate as an interagency group, with representation from state and local governments, advisory to the President and Congress.

To satisfy the launch requirements of future applications satellites, outlined by the user community at the study, the Board recommended that plans for the Space Shuttle offer an early capability to place payloads in both polar and geosynchronous orbits. Specific recommendations were also made for implementing practical applications in the following areas: hazardous weather warnings and long-range weather and climate predictions; land-use planning, agriculture, forest, and range management; exploration for food, water, energy, and mineral resources; and environmental monitoring.

The Board has concentrated its 1975 activities on dissemination of the findings and recommendations of the study.

Committee on Remote Sensing Programs for Earth Resources Surveys

The Committee on Remote Sensing Programs for Earth Resources Surveys (CORSPERS) provides advice to the Federal government on the use of remote sensing from spacecraft and aircraft for Earth-resource management and environmental monitoring. After completing a major study on the usefulness of remote sensing in late 1974, the Committee activity during 1975 was primarily addressed to responding to follow-on questions from individual Federal agencies. One was on the utility of remote sensing in ground-water quality management; another related to evaluating the full potential of remote sensing to assist a particular agency.

The Committee has initiated a major study to evaluate the concept of having the Thematic Mapper, a second-generation Landsat sensor, provide a repetitive matrix of high-quality land-cover information as basic information for all users and then supplement this with data from user-specific missions as necessary. While this study may take 18 months, interim reports will be made along with preliminary conclusions.

Committee on Radio Frequencies

The Committee on Radio Frequencies (CORF) and its Subcommittees on Space Sciences, Radio Astronomy, and Earth and Life Sciences coordinate the views of the U.S. scientific and engineering communities on radio frequencies needed for research. CORF is working closely with Study Group 2 of the U.S. National Committee for the International Radio Consultative Committee (CCIR) in preparing documents on space research and radio astronomy for the CCIR Study Group 2 meeting to be held in Geneva in March 1976.

Recommendations concerning frequency allocations for the radio astronomy service were prepared and submitted by CORF to the Federal Communications Commission (FCC) for use in preparing the U.S. position for the 1979 World Administrative Conference.

Additional tests were conducted by the radio astronomy observatories to study the interference by transmissions from ATS-6.

Aerospace Engineering

Aeronautics and Space Engineering Board

The Aeronautics and Space Engineering Board (ASEB) was organized to focus the talents and energies of the engineering community on significant aerospace policies and programs considered essential to maintaining and improving the contributions that can be made by this important sector of the nation's economy. In 1975 the Board reviewed and commented on NASA's proposed research and development programs in aeronautics and space.

As its contribution to the National Energy Program, the ad hoc Committee on Aircraft Fuel Conservation reviewed and made suggestions on plans and programs to increase emphasis in those specific areas of research and technology focusing on early development of a fuel-conservative aircraft.

In a related area of aeronautics, an ad hoc Committee on Supersonic Cruise Aircraft Research and Technology reviewed progress in this area and was pleased to note that the special emphasis on certain facets of work previously recommended had produced new concepts of potential importance to future commercial and military aircraft. This Committee plans to continue to monitor NASA's supersonic research and technology program and to continue to offer comments and recommendations as appropriate.

In the area of space activities, the Board's ad hoc Committee on the Management of Space Program Costs met in conjunction with two NASA Project Manager Workshops to determine what steps can be taken to reduce costs by learning from earlier and on-going projects in NASA. As a result, several steps are now under way which should help future NASA project managers to meet performance, cost, and time goals. The most recent Committee created by the Board, the ad hoc Committee to Review Requirements for National Turbine Engine Test Facilities, is reviewing the need for those additional facilities for the development and ground-based testing of superior gas turbine engines on succeeding generations of commercial and military aircraft.

During the coming year the ASEB plans not only to continue to review the nation's overall aerospace research and development program, but also to create ad hoc groups, when needed, to review in depth and comment on areas of critical importance.

National Materials Advisory Board (NMAB)

The general goal of NMAB is the advancement of materials science and engineering in the national interest. The scope of the activity covers the entire life cycle from raw material through finished product and the recycle of the spent product into the processing system. A significant portion of the Board's activities pertains to aerospace materials. The NMAB completed several studies in 1975 which address specific problems in aerospace materials technology and propose solutions.

The report of the ad hoc Committee on Implementation of Cost-Saving Recommendations for Aerospace Construction identified factors that have a major influence on cost in airframe, engine, and helicopter procurement. These factors were used as a basis for proposing structures and materials programs aimed at reducing costs.

Another NMAB ad hoc committee completed its study of structural ceramics. The principal objective was to evaluate the advances in the uses of ceramics as load-carrying structural materials, and make recommendations for future developments.

In its report, "Characteristics of HY-180 and Ti-100 for Welded High Strength Structures," the ad hoc Committee presented the present state of the art and identified developments necessary for successful commercial application for high-strength materials in welded structures. A general review of the problems and the potential of the various welding processes is included and those processes are identified which show greatest promise and should be further developed.

Although it was a minor part of the overall study, the report of the ad hoc Committee on Mechanical Rope and Cable did address the use of wire rope in aerospace systems. The general assessment of factors including design, materials, environment, wear, maintenance, and fittings is applicable. Conclusions are drawn regarding the need to determine by nondestructive evaluation a rope's service life, the extent of internal corrosion, and wear.

Education

Commission on Human Resources

A postdoctoral Resident Research Associateship Program is administered for NASA by the National Research Council through its Commission on Human Resources. Carefully selected postdoctoral scientists and engineers have an intensive research experience in areas of interest to the NASA centers at which the Associates are on tenure. The program strengthens the research efforts of the host centers and constitutes a major means for staff stimulation because of the interaction with these talented visitors. There were 166 Associates on tenure on August 31, 1975.

XI

Office of Telecommunications Policy

Introduction

The Office of Telecommunications Policy (OTP) was created in 1970 as an independent agency within the Executive Office of the President. OTP has three major functions: (1) to serve as principal advisor to the President on communications policy; (2) to establish policies and provide coordination for the Federal government's communications system; and (3) to serve as spokesman for the Executive Office on communications matters.

As specified in its charter, OTP develops plans, policies, and programs with respect to communications designed to promote the public interest, support national security, contribute to the economy and world trade, promote the interests of the United States in its relations with foreign nations, and foster effective and innovative telecommunications technology.

During the past year, OTP was active in a broad range of telecommunications issues involving the application of aeronautics and space technology.

Aeronautical and maritime mobile satellite systems continue to be the subject of international discussions. In 1974, a Memorandum of Understanding was signed by the Department of Transportation, Federal Aviation Administration; the European Space Research Organization (ESRO), now the European Space Agency (ESA); and the government of Canada for an experimental aeronautical satellite system (AEROSAT) to serve international civil aviation requirements in the North Atlantic region. During the past year, the AEROSAT Council, which provides overall program direction, met four times. At the end of the year, OTP, along with the DOT/FAA and the Department of State, was reviewing program objectives and funding arrangements in the light of escalating costs in the space segment.

International talks are continuing on the structure of a proposed intergovernmental organization designed to provide maritime mobile communications by satellite. During the past year, OTP has provided a forum for discusions among interested governmental and industry sectors in the United States on the desirability of U.S. participation in the proposed International Maritime Satellite System (INMARSAT).

OTP has introduced legislation to Congress that would amend the Communications Satellite Act of 1962; the amendments are designed to reflect changes that have occurred since the time of the original legislation.

The possibility of the use of telecommunications satellites for broadcast of television programs directly into home receivers continues to generate international debate in the United Nations. OTP participated in the discussions that took place during the Fourteenth Session of the Legal Subcommittee of the United Nations Committee on the Peaceful Uses of Outer Space on the drafting of principles to serve as a basis for a proposed international convention on Direct Broadcasting.

The Office makes a continuing review of the demands for use of the radio spectrum, which is a limited natural resource. During the year, OTP, in cooperation with the FCC and the Department of State, was active in preparing for three important up-coming international conferences regarding frequency allocation for aeronautical, space, and terrestrial telecommunications systems. The conferences are sponsored by the International Telecommunications Union, a specialized agency of the United Nations.

Finally, OTP, in cooperation with the Office of Management and Budget; the Department of Health, Education and Welfare; and NASA has been active in encouraging the transfer of the technology involved in the ATS-6 program to the private sector. NASA's ATS-6 program has developed considerable interest in using advanced communications satellites with low-cost Earth stations to deliver health and educational services to remote sections of the country. To make these services regularly available to those who need them most, they must be shifted from the experimental NASA realm into the operational realm. As a result of this stimulus, the Public Service Satellite Consortium was formed early in 1975. At the same time, OTP is examining the possible benefits that government agencies could realize by continued, expanded use of the ATS-6 satellite.

AEROSAT

OTP issued policy guidelines for the development of a national program on satellite communications for international civil aviation in early 1971. After three years of negotiation by the Department of Transportation's Federal Aviation Administration (DOT/FAA) and the Department of State with foreign authorities, a Memorandum of Understanding was signed in 1974 by DOT/FAA, the European Space Research Organization, the predecessor of the European Space Agency, and the government of Canada concerning a joint program to test the use of satellites for improving air traffic control. The AEROSAT program is experimental, designed to explore ways of using satellites to improve the cost effectiveness of oceanic en route services, including the possibility of reducing air traffic control facilities.

Consistent with the policy guidelines of the joint European/Canadian/U.S. aeronautical satellite program (AEROSAT), COMSAT General is the U.S. industrial partner and the FAA is its only customer for use of the satellite. The space segment would be jointly owned by the European Space Agency and COMSAT General, each having 47 percent, and Canada having 6 percent.

During 1975, the AEROSAT Council met four times. The issuance of a request for proposals for the principal development contract has been delayed until early next year. At the end of the year, OTP, DOT/FAA, and DOS were reviewing program costs and funding arrangements.

INMARSAT

Beginning in 1972, an international Panel of Experts (POE) from 20 major countries began considering, under the auspices of the Intergovernmental Maritime Consultative Organization (IMCO), a specialized organ of the United Nations, the possibility of establishing an international global maritime satellite communications system. The satellite system would provide public telecommunications, as well as safety and radio location determination services, on a global basis for merchant ships at sea.

In the fall of 1974, the IMCO-POE completed its work and wrote a report which included, *inter alia,* a recommendation that a new Intergovernmental Maritime Satellite Organization (INMARSAT) be created. The United States had participated in the work of the IMCO-POE, but had reserved its position with respect to the report. The U.S. requested that a note of its reservations be included in the Panel's report. This note expressed certain reservations about the desirability of creating such an organization, and particularly the necessity to do so at this time.

From January to March 1975, OTP initiated a policy of reexamining the U.S. position on this matter and played a key role in providing a forum for discussions among interested government agencies and sectors of industry regarding the desirability of U.S. participation in the proposed INMARSAT organization in preparation for an IMCO conference scheduled for April. In April 1975, an International Conference on the Establishment of an International Maritime Satellite System was held in London, England, under the auspices of IMCO. During that conference, the U.S. delegation pointed out that, for the U.S. to become a member of the proposed organization, certain conditions would have to be met. These conditions included such requirements as a two-part agreement specifically delineating the rights and responsibilities of designated entities, the requirement that the Council be the supreme organization for practical purposes, and generally that procurement policy be competitive. In this light, it is fair to conclude that the conference was quite successful from the point of view of the U.S. International talks are continuing on the structure of the proposed organization, and OTP participated in three Intersessional Working Group Meetings in preparation for the next plenary meeting in February 1976.

Along with other U.S. agencies, the Office is drafting legislation which will be required for U.S. participation in the proposed intergovernmental organization.

Proposed Amendments to the Communications Satellite Act of 1962

The Office of Telecommunications Policy submitted legislation to Congress that would amend the Communications Satellite Act of 1962. This legislation is now pending before the Senate Commerce Committee (S.1693) and the House Committee on Interstate and Foreign Commerce. The 1962 Act, which called for the creation of a commercial satellite system as part of an improved global communications network, established the Communications Satellite Corporation (COMSAT) as the chosen instrument of the United States for accomplishing the purposes of the act.

Generally, the amendments are designed to update the act in response to present conditions in international communications, but these amendments do not alter the basic policy premises underlying the original legislation. In 1962, a number of technical and operational uncertainties regarding the creation of COMSAT gave rise to the inclusion of several provisions relating to COMSAT's ownership and the conduct of its affairs, provisions not normally associated with a private communications common carrier enterprise. With the emergence of COMSAT as an established and mature corporation, the proposed changes would:

(1) eliminate the requirement that COMSAT incorporate in the District of Columbia;

(2) repeal the provision calling for presidentially-appointed and common-carrier-elected directors;

(3) eliminate the special class of common carrier stock;

(4) reduce permissible common carrier shareholding to five percent;

(5) permit COMSAT to issue par value stock;

(6) repeal the requirement for COMSAT to obtain FCC approval prior to obtaining additional capital.

Additionally, the possible emergence of specialized international satellite systems that would be separate from the INTELSAT system is also recognized. One amendment would make explicit that COMSAT could participate in such new international systems, on a non-exclusive basis, thus legislatively affirming an FCC rule-making decision to the same effect in the context of domestic satellite systems. Another amendment clarifies the Executive Branch role in the planning, implementation, and operation of new international satellite systems that are developed pursuant to international agreement in which the U.S. is a party.

Direct Broadcast Satellites

The essential difference between the proposed direct broadcast satellites and conventional communications satellites is the former's capacity to broadcast directly into home receivers, avoiding expensive ground stations. The use of receivers designed for direct broadcast satellite reception offers the potential for radical changes in the way telecommunications satellites may be employed.

The United Nations has served as the forum for debate on the issue of Direct Broadcast Satellites since 1972, when 102 States voted for a Soviet Union-sponsored resolution by which the General Assembly considered it necessary to elaborate principles governing the use by States of Direct Broadcast Satellites with a view toward concluding an international convention.

The United States voted against this resolution as not necessary, pointing out that there are international legal instruments which impact on the question of direct broadcast satellites already—for example, the United Nations Charter, the Outer Space Treaty, applicable provisions of the International Telecommunication Convention and Radio Regulations, certain relevant principles expressed in the Universal Declaration of Human Rights, and Resolutions of the General Assembly. Moreover, the United States has stressed the concept of free flow of information in the debates.

During February and March of 1975, the Legal Subcommittee of the United Nations Committee on the Peaceful Uses of Outer Space met for its fourteenth session to discuss, among other things, direct television broadcasting. Fourteen topics were agreed to as a basis for drafting. Of the fourteen topics, in only three were the texts of the draft principles agreed to by all members of the Subcommittee. Generally, unanimity is a necessary condition for a proposed convention to exit the Legal Subcommittee for final vote in the General Assembly. Although there was unanimous agreement on three of the principles, there was no consensus in the remaining eleven topics and, in a number of instances, the differences were fundamental. The issue that continues to attract the most controversy and in which there are still fundamental differences is that of prior consent—the notion that no State should be allowed to engage in direct television broadcasting without prior approval of the State which may be the intentional or unintentional recipient.

In June of this year, the Committee on the Peaceful Uses of Outer Space (Outer Space Committee) met in New York to examine the reports of its Technical and Legal Subcommittees. Regarding the report of the Legal Subcommittee on Direct Television Broadcasting, the Outer Space Committee expressed satisfaction with the set of principles drafted by the Legal Subcommittee and agreed that work should continue. The next session of the Legal Subcommittee is scheduled for Geneva in 1976.

OTP, along with other interested U.S. agencies, participated in the deliberations of both the Legal Subcommittee and the Outer Space Committee during the year, and it will continue its contribution to the formulation and presentation of U.S. policy views on Direct Television Satellite Broadcasting.

Frequency Management

The radio frequency spectrum is a finite resource. Its application is subject to the laws of physics; and it is shared by all nations and by all classes of radio equipment. Discrete segments of this radio spectrum are used by navigational aids, radars, and all non-wire forms of communication, e.g., AM, FM, and TV broadcasting; satellite transmission; and mobile communications generally. Today, the use of the radio spectrum affects the day-to-day activity of every citizen and every government agency. Increasing use increases the potential for interference. Avoiding such interference is a function of frequency management.

National frequency management, including spectrum planning, is carried out by the staffs of OTP and the Federal Communications Commission (FCC). The Interdepartment Radio Advisory Committee (IRAC), made up of representatives of major Federal government departments and agencies using radio, provides substantial support to OTP. The main body of the IRAC meets several times a month to address major radio frequency policy issues and to consider the recommendations of numerous working groups that analyze specific problems.

International spectrum planning is done within the framework of the International Telecommunications Union (ITU), a specialized agency of the United Nations. Established in 1865, it is the oldest international body in the U.N. structure. Located in Geneva, Switzerland, the ITU is composed of 144 members. The international radio regulations negotiated at conferences of the ITU, when ratified by the U.S. Congress, have the force of treaty. In addition to the relevance of the ITU regulations to national use of the radio frequency spectrum, they have an explicit impact on international communications and commerce. OTP, the FCC, and the Department of State are pursuing preparatory work for three ITU conferences:

- A World Administrative Radio Conference to be held in January 1977 to establish technical sharing criteria for the Broadcasting Satellite Service in the 11.7–12.2 GHz frequency band, taking into account the fixed, mobile, and other broadcasting operations to which that band is also allocated;
- A World Administrative Radio Conference to be held in March 1977 to revise the planning for the Aeronautical Mobile Service use of high frequencies on the world's air-route communication systems:
- A World General Administrative Radio Conference to be held in the second half of 1979. This conference will have the authority to review and revise all of the international radio regulations, particularly those dealing with allocation of the radio frequency spectrum. The last ITU conference to have such broad authority was held in 1959. The advent of satellites and other sophisticated telecommunication technology, combined with the influx of 46 new members into the organization since 1959, each making further demands on this limited resource, and an increasingly political atmosphere at recent past conferences indicate that the 1979 meeting will present the U.S. with greater challenges than any ITU-sponsored conference in the history of the organization.

In undertaking preparatory work for these conferences, OTP has identified a dangerous level of attrition in qualified frequency management personnel, particularly those having international conference experience. In cooperation with the Civil Service Commission, a comprehensive Career Development Plan for government frequency managers has been developed and implemented. Personnel at the executive, mid-level, and entry-level will be prepared for international negotiations, technical analysis, regulatory enforcement, and decision processes essential to frequency management.

At the initiative of OTP, detailed examinations of planned and proposed aeronautical radionavigation and satellite systems have been undertaken jointly with the sponsoring government agencies to evaluate their electro-magnetic interactions with each other and with existing systems. As a result, a number of design adjustments in planned systems have been made by the FAA, NASA, and DOD. These engineering analyses, undertaken at the conceptual and design stages, have avoided inestimable expenses in hardware replacement or retrofit, which would have been necessary had the interference problems gone unresolved prior to the production or operational stages.

High Power Satellites

As a result of the recent ATS-6 program of NASA, considerable interest has developed in using advanced communications satellites with low-cost Earth stations in the delivery of health and educational services. With such a satellite communications system, even the most remote regions of this country can have access to such services through television. The economic advantages of such satellites are great if the user base is large enough.

OTP, in conjunction with OMB, HEW, and NASA, encourages the transfer of this technology to the private sector. For such services to be useful to those who need them, they must be shifted from NASA's experimental mode into the real world of operational needs. While NASA has done a good job of eliminating technical barriers associated with this type of satellite, questions of demand and how to bring all the many potential users together into a useful economic market have prevented any major private sector initiative in this area.

To correct this situation, OTP and HEW supported the concept of a user consortium that could collect all the various user needs for such service into a single package. As a result, the Public Service Satellite Consortium was formed early in 1975. The ultimate purpose of this organization is to make high-powered communication satellite services available to public and private institutions concerned with the delivery of health, educational, and other public services.

In a related issue, the use of the ATS-6 satellite by Federal agencies such as the Veterans Administration and the Indian Health Service indicated the possibility of continued and additional Federal uses of similar services in the future. OTP therefore examined the possible benefits that might be derived from expanded Federal use. This effort included determining what coordination, if any, was needed within the Federal government in technical and funding support which might be provided to non-Federal users of such a service—support aimed at encouraging the evolution of a viable and independent user community. To accomplish these tasks, OTP formed the Interagency Committee on Communications Satellite Technology Applications in January 1975. The initial membership consisted of those agencies that had demonstrated interest in the ATS-6 type of programs and included NASA, HEW, HUD, Commerce, VA, NSF, and the Law Enforcement Assistance Administration. If the Committee determines that significant Federal needs for such satellite services do exist and that the Committee can serve a useful function, the membership will probably be expanded to include other Federal agencies.

The Committee has met twice and is engaged in an analysis of basic issues which must be resolved before any real progress in advancing this new technology can be expected. One of these issues centers on the frequency band that would be most useful in facilitating Federal use of high-powered satellite services. The frequency band used by ATS-6 has serious limitations and much investigation is going on of the usefulness of higher bands. In addition, the Radio Regulations place restrictions on Federal activities in what is normally considered to be civilian frequency bands.

The Committee is investigating the potential uses of the ATS-6 spacecraft when it returns from India where a year-long experiment in instructional television is presently being conducted. The Committee is similarly addressing the use of the Communications Technology Satellite after a joint experiment with the Canadians is completed.

XII

Federal Communications Commission

Introduction

The furtherance of the United States policy to establish a communications satellite system which will be responsive to public needs and national objectives and which will contribute to world peace and understanding is indicated by the increase in membership in INTELSAT from 86 in 1974 to 91 in 1975. Three domestic U.S. satellite systems continue to broaden the services offered to the public, including communications services to cable television system operators and to offshore drilling platforms. Operation of a maritime satellite system is scheduled to begin in early 1976 with the provision of service to the Navy.

Communications Satellites

INTELSAT

The INTELSAT system presently consists of three Intelsat IV satellites (two operational and one spare) in the Atlantic Ocean Region, two Intelsat IV satellites (one operational and one spare) in the Pacific Ocean Region, and two Intelsat IV satellites (one operational and one spare) in the Indian Ocean Region. The first of the Intelsat IVA satellites was launched September 25, 1975, with operations scheduled to begin in December in the Atlantic Region. A request for proposals has been issued for a future generation of satellites designated as the Intelsat V series.

The worldwide network of Earth stations has grown to 112 antennas at 89 stations sites in 64 countries. Besides providing international communications, INTELSAT is providing satellite capacity to meet the domestic communications requirements of several countries. The additional antennas under construction at the Etam, West Virginia, and the Andover, Maine, Earth-station sites are scheduled for completion by December 31, 1975, with operation commencing shortly thereafter. The continued construction of Earth-station facilities is just one indication of the growing reliance on satellites for international as well as domestic communications.

Domestic Satellites

In addition to the continuation of domestic satellite services by the American Satellite Corporation, RCA Alaska Communications, Inc., RCA Global Communications, Inc., and Western Union Telegraph Company, several significant new uses of domestic satellites developed during 1975. The use of domestic satellites to distribute pay cable programming to cable television (CATV) systems began in the fall through receive-only Earth stations owned by the CATV system operators. Commercial service to a small Earth terminal on an offshore drilling platform in the Gulf of Mexico was also begun in the fall, and construction of twenty small earth terminals to serve rural communities in remote locations in Alaska was begun under a waiver of the rules issued by the Commission.

Operations of the interim domestic satellite system of RCA Global Communications, Inc., and RCA Alaska Communications, Inc., were transferred from the Telesat Canada Anik satellites to the Westar II satellite of the Western Union Telegraph Company in early 1975 after the Westar II was temporarily relocated to an orbital location more suitable for serving Alaska. The launch of the first RCA satellite took place in mid-December.

Construction of the American Telephone & Telegraph Company (AT&T) domestic satellite system authorized in 1973, using satellites owned by Comsat General Corporation, was completed, with commercial service expected to begin in early 1976. Hearings were completed and an initial decision issued by an administrative law judge on the proposal filed in 1974 by GTE Satellite Corporation to use these satellites together with AT&T, instead of using satellites authorized in 1973 to National Satellite Services (a subsidiary of Hughes Aircraft Company). The Commission is expected to reach a final decision in this matter by the end of the year.

Although no new domestic satellite systems were proposed to the Commission during 1975, the Commission rejected a proposal filed in 1974 for a major restructuring of the CML Satellite Corporation which would result in 45-percent ownership of CML by Comsat General and 55-percent by IBM. The Commission did set forth several alternatives under which IBM could enter the domestic satellite industry. One of these alternatives, under which CML would be jointly owned by Comsat General, IBM, and a third party, was selected. In late September the Commission was informed that Aetna Casualty & Surety Co. was chosen as the third partner. Formal applications were filed in late December 1975. The proposed system would operate in the 12 and 14 GHz frequency bands to provide integrated voice, data, and image communications services between Earth stations located on customer premises throughout the 48 contiguous states.

Specialized Satellite Services

Maritime Mobile Satellite Service

The Commission is continuing to work both nationally and internationally to further the development of a maritime mobile satellite service. Such a service will significantly improve maritime communications in accuracy, reliability, speed, and variety of transmission modes, all of which will enhance maritime safety and management.

Internationally, the Intergovernmental Maritime Consultative Organization (IMCO), through the Panel of Experts on Maritime Satellites, completed its final meeting in September 1974, looking toward the establishment of an international maritime mobile satellite service. Operational requirements have been stated and initial economic, technical, and financial studies have been completed. An initial conference of governments, which considered the report of the Panel of Experts, was completed in May 1975. In preparation for that conference, the Commission instituted an inquiry to help formulate the U.S. position on the establishment of an international maritime satellite system. At that conference it was agreed that "in order to improve maritime communications, there was a need for a world-wide maritime satellite system and also that there was a need for an International Inter-Governmental Organization to administer and manage this system." A second session of the conference is planned for February 1976 to discuss arrangements for the establishment of the International Organization for a Maritime Satellite System (INMARSAT).

In April 1973, the Commission issued waivers allowing the construction of three satellites that will be part of a five-year system intended to provide service to the Navy as well as to maritime users, beginning in early 1976. One satellite is planned for deployment over the Atlantic and another over the Pacific with the third held as a spare on the ground. In August 1973, the Commission provided for a consortium of four carriers to participate in this Navy/maritime system and has issued several orders concerning this matter, the most recent being in May 1975. In September 1975, the Commission proposed rules for licensing commercial ships to operate in such a system.

The Navy communications services will be provided in the UHF band on a lease basis for a period of years beginning in 1976. The satellite capacity used by the Navy will be under its control and will be used to provide fleet communications. The satellite design is such that during the period of the Navy service, a large portion of the satellite power will be required to meet the naval requirements; the remaining power will be available for commercial maritime use. When the Navy no longer requires this service, the entire satellite power can provide commercial maritime service.

Aeronautical Mobile Satellite Service

In the fall of 1974, a memorandum of understanding was signed by the Department of Transportation/Federal Aviation Administration, the European Space Research Organization (ESRO), and the Canadian government on the basic arrangements for establishing an experimental aeronautical satellite system in the North Atlantic. Comsat General Corporation has been chosen as the U.S. co-owner in the space segment of the system, which is to be evaluated beginning in early 1978.

The objectives of the program are to gain experience and to evaluate and experiment with the use of satellites in providing voice and data communications between aircraft and land stations. The system will use frequencies at C-band for communications between ground stations and satellites. Between satellite and aircraft, it is anticipated that this initial system will provide limited VHF capability (the frequencies now used by civilian aircraft over land) in addition to an L-band capability.

Broadcasting-Satellite Service

A series of broadcasting-satellite experiments began in June 1974 with the Applications Technology Satellite, ATS-6. Further broadcasting-satellite experiments are planned with the joint United States/Canada Communications Technology Satellite (CTS), which is scheduled to be launched in early 1976.

At present, there are no applications before the FCC for this new use of the radio spectrum. However, the Commission is investigating the needs for a Broadcasting-Satellite Service for community and individual reception and has initiated a proceeding as part of the preparation for the 1977 ITU World Administrative Radio Conference for planning a

Broadcasting-Satellite Service. (See "International Telecommunication Union (ITU).") Also, a report titled, "The Present Status of Broadcasting Satellites" (FCC/OCE RC75-06) was issued by the Chief Engineer's office in September 1975.

International Telecommunications Union (ITU)

During 1975, the Commission's activities increased in the area of international advance publication, coordination, and notification about space systems, in accordance with provisions of the ITU radio regulations. This increase stemmed primarily from the several domestic satellite systems in use or under development; it also arose from U.S. responsibilities to carry out these functions on behalf of INTELSAT countries.

Commission personnel developed rulemaking to implement the results of the 1974 Maritime World Administrative Radio Conference, which, in part, adopted regulations for the maritime mobile-satellite service.

The Administrative Council of the ITU, which met during the summer of 1975, reconfirmed the convening of a General World Administrative Radio Conference and set a date for the second half of 1979. This major conference will deal with overall revisions to the current international regulations governing all radio services, including the aeronautical and space services. The Council agreed to the convening of a special joint meeting of the International Radio Consultative Committee (C.C.I.R.) in the second half of 1978, to consider technical factors in preparation for the 1979 General Radio Conference.

Because of the wide scope of the forthcoming General Radio Conference, extensive preparatory work is well under way, taking into account the frequency requirements of all radio services and the many other technical and operating aspects involved. The Commission is soliciting public comments to assist in the development of U.S. proposals.

Preparatory work has continued for the Satellite Broadcasting World Administrative Radio Conference scheduled for January 1977, to plan for the use of the frequency band 11.7–12.2 GHz now allocated for use by fixed services, fixed satellite services, mobile services, broadcasting services, and broadcasting satellite services. Preparatory work was also initiated for the Aeronautical World Administrative Radio Conference to be held March 1977. This conference will deal with matters relating to the Aeronautical Mobile Route Service, including the revision of their frequency allotment plan on the basis of single-sideband operation.

Frequency Allocation and Coordination

An order was adopted January 3, 1975, to delete footnote US96 to the Table of Frequency Allocations. US96 allowed the use of certain frequencies in the non-government band, 1990–2110 MHz, by the government in support of the Apollo space program. Since there is no longer a need for these frequencies, the provision has been deleted.

The Commission has amended its rules by adding a new footnote, US219, to the Table of Frequency Allocations to permit the use of the frequency 2106.4 MHz by Government Earth stations for Earth-to-space transmissions. This action was requested by the Department of Interior through the Interdepartment Radio Advisory Committee of the Office of Telecommunications Policy. The Department of Interior will use this frequency in their Earth Resources Survey Operational System to collect and disseminate a wide variety of essential data on the natural resources. This provision was effective Feburary 19, 1975.

An order was adopted March 12, 1975, to allocate the band 1700–1710 MHz to government and non-government meteorological-satellite service on a co-equal primary basis with the existing space research service. The Department of Commerce requested this allocation for implementing a new satellite system, the Television Infrared Observation Satellite. This new system uses an RF bandwidth of 15 MHz and would cause problems to another satellite system if required to use the formerly allocated band 1670–1700 MHz.

A Notice of Proposed Rule Making was adopted September 5, 1975, to add a new footnote, US222, to the Table of Frequency Allocations. The new footnote would permit the use of frequency band 2025–2035 MHz by government Earth stations for Earth-to-space transmissions for tracking, telemetry, and telecommand at Wallops Island, Virginia; Seattle, Washington; and Honolulu, Hawaii. The new footnote was requested by the Office of Telecommunications Policy to make provision for the Geostationary Operational Environmental Satellite System (GOES) to operate in the 2025–2035 MHz band. GOES will be used in short-range forecasting and warning of weather, ocean, and solar hazards, providing nearly continuous, detailed observations.

XIII

Department of State

Introduction

International space cooperation efforts in support of foreign policy objectives and the goals of the National Aeronautics and Space Act were a matter of high priority to the Department of State during 1975. Attention continued to be focused both on cooperation with individual countries and on space endeavors with multilateral and international organizations.

Particular progress was seen in support of efforts toward a European community by the cooperation of NASA with ten countries in their development of a large space laboratory for use with the U.S. Space Shuttle system. Support of bilateral relations with the U.S.S.R. continued through the joint Apollo-Soyuz Test Project, which was successfully completed, and scientific exchanges. International cooperation for peaceful uses of space by all mankind was advanced in the communications satellite programs, the emerging maritime and aeronautical satellite programs, and the continued interest in space matters in the United Nations. The United Nations, through its Outer Space Committee and various working groups, has continued to be a prime forum for the formalization of multinational viewpoints and programs to advance cooperation in the uses of outer space.

Activities Within the United Nations

Outer Space Committee

Meeting in New York from June 9 to 20, the Committee on the Peaceful Uses of Outer Space reviewed the reports of its subcommittees and recommended further consideration of the three principal topics under consideration: direct television broadcasting satellites, remote sensing, and a draft Moon treaty.

Regarding the use of satellites for direct television broadcasting, the Committee expressed satisfaction with the progress made to date by its Legal Subcommittee in drafting a set of principles governing such use. The Committee noted that these draft principles included formulations on which consensus had been reached as well as those on which consensus could not be reached. There was no significant progress in resolving the critical differences between adherents of the prior-consent concept and of the concept of freedom of information (supported by the U.S.). The Committee agreed that the Legal Subcommittee should at its 1976 session continue to consider as a matter of high priority the elaboration of principles governing the use by states of artificial Earth satellites for direct television broadcasting with a view to concluding an international agreement or agreements.

Of the three main topics, remote sensing of the Earth's resources and natural environment by satellite from space received the greatest amount of attention during the meeting. In the working sessions the principal focus was on the future mandate of the Legal Subcommittee which had considered the question of remote sensing this year for the first time. The principal points of contention were whether prior consent was necessary for the acquisition and distribution of remote sensing data. The Committee finally agreed that the Subcommittee should as a matter of high priority (a) continue its detailed legal consideration of remote sensing of the Earth from space with a view to identifying further common elements among the views of states, and (b) proceed to drafting principles where common elements in the views of states were identified. The Committee noted with satisfaction the work of its Scientific and Technical Subcommittee, confirmed that further studies of the organizational and financial aspects of remote sensing should progress together with consideration of the legal aspects, and endorsed the Subcommittee's recommendations concerning future studies and actions by the Secretary General.

The Committee noted the work of the Legal Subcommittee on developing a draft Moon treaty. The Subcommittee discussions were devoted almost entirely to negotiations on formulas concerning exploration and exploitation of the Moon's resources. Also unresolved were two previous issues of whether the treaty should apply to other celestial bodies and the extent to which launching states should give information on their missions to the Moon. The Committee agreed that at its next session the Legal Subcommittee should, as a matter of high priority, continue its consideration of a draft treaty.

The Committee noted and endorsed the other recommendations of its subcommittees, but was unable to reach agreement on the convering of a United Nations conference on space applications. The Scientific and Technical Subcommittee was requested to consider the desirability of holding such a conference. The Committee voiced the opinion that the practice of rotating meetings of the Legal Subcommittee between New York and Geneva should be maintained.

General Assembly

The traditional two outer space items, "International cooperation in the peaceful uses of outer space", and "Preparation of an international convention on principles governing the use by States of artificial earth satellites for direct television broadcasting", were considered by the First Committee of the General Assembly during October 10-15. Fifty-two delegations spoke on various outer space issues, with particular attention devoted to remote sensing. The statements reflected a growing recognition among many states of the potential contributions which analysis of remote sensing data could make to their own national economic development plans. On October 15 the First Committee unanimously adopted a draft resolution (sponsored by 42 countries including the United States) which recommended that the Legal Subcommittee should, as matters of high priority, a) continue consideration of a draft Moon treaty, b) continue to consider elaboration of principles governing the use of artificial Earth satellites for direct television broadcasting, and c) continue detailed legal consideration of remote sensing with a view to identifying further common 'elements among the views of states and proceed to drafting principles where such common elements are identified. The resolution also endorsed the other recommendations of the Committee on the Peaceful Uses of Outer Space, including those calling for further studies and actions by the Secretary General and those concerning the priorities of future work for the Scientific and Technical Subcommittee. The draft resolution was adopted unanimously by the General Assembly on November 18.

International Cooperation

Cooperation with Europe

In March NASA concluded an agreement with the European Space Research Organization (which became the European Space Agency (ESA) as of May 31, 1975) to undertake a joint cooperative project to study solar-terrestrial relationships. This will be a joint contribution to the International Magnetospheric Study, a multilateral scientific program established by the Committee for Space Research and Interunion Commission on Solar Terrestrial Physics of the International Council of Scientific Unions. The understanding envisages the launching in 1977 of joint ESA-NASA Sun Earth Explorer A and B satellites from the Kennedy Space Center. The objectives of the mission are to investigate solar-terrestrial relationships in the Earth's magnetosphere, solar wind, and cosmic rays and solar flares. Each party will design and fabricate one of the satellites for the mission.

Cooperation continues between ESA and NASA on the European project to develop the Spacelab for use with NASA's Space Shuttle.

Cooperation with Japan

Space cooperation between the U.S. and Japan during 1975 was dominated by a continued flow of space hardware and technology to Japan, as authorized under terms of the 1969 United States-Japan Space Cooperation Agreement. These exports are being transferred under United States-Japan industry arrangements, subject to the approval of the Department of State's Office of Munitions Control, and are to be used in Japanese efforts to develop a space-launch vehicle and a number of scientific and practical applications satellites. The first launch of the Japanese N vehicle and an engineering test satellite occurred in September and was completely successful.

An agreement has been concluded for NASA to furnish reimbursable launches of three Japanese satellites. The first is a meteorological satellite to participate in the international Global Atmospheric Research Program. The second is an experimental communications satellite; the third is an experimental broadcast satellite.

Cooperation with the Soviet Union

The joint Apollo-Soyuz Test Project was safely and successfully completed in July 1975. Both Apollo and Soyuz lifted off on July 15, 1975. This mission demonstrated compatible rendezvous and docking systems and made a major contribution to rescue capability for future manned space flights. The astronauts and cosmonauts exchanged visits between vehicles and carried out five scheduled cooperative experiments. The plan for coordination of joint flight activities between Houston and Moscow control centers was closely followed with excellent results. Television coverage included the dramatic link-up in space. This milestone in U.S.-Soviet cooperation was capped by visit of the astronauts to several major cities in the U.S.S.R. followed by a reciprocal tour of the U.S. by the cosmonauts.

Also under the U.S.-U.S.S.R. agreement concerning cooperation in the exploration and use of outer space, a joint Working Group meeting on Space Meteorology was held at the Goddard Space Flight Center March 3-6, 1975. Cooperative plans were developed in areas such as microwave observation of sea surface and temperature, which have the potential of improving the meteorological services in both countries.

Finally, also under the Space Agreement, firm plans were completed in August at a meeting at the NASA Ames Laboratory for joint space biological experiments. In late 1975, a Soviet satellite flew four U.S. self-contained experiments with live biological material.

Technology Transfer

In 1975 the bulk of license requests for export of space-related hardware and technology processed by the Department of State's Office of Munitions Control involved transfer under the United States-Japanese Space Cooperation Agreement and exports to Europe. The Department continued to emphasize the export of hardware rather than the technology necessary to produce the hardware.

Satellite Services

Communications Satellites

The definitive agreements establishing the International Telecommunications Satellite Organization (INTELSAT) entered into force February 12, 1973, and membership in INTELSAT reached 91 as of September 12, 1975, with the completion of membership requirements by Libya, Oman, and Panama. The definitive agreements consist of an inter-governmental agreement and an operating agreement. The U.S. is a party to the former, and designated the Communications Satellite Corporation (COMSAT), a U.S. company, to be its signatory to the latter. INTELSAT has a structure consisting of an Assembly of Parties, a Meeting of Signatories, a Board of Governors, and an Executive Organ under the direction of a Secretary General responsible to the Board of Governors. During 1975 COMSAT participated in the third session of the Meeting of Signatories and represented the U.S. at the bimonthly meetings of the Board of Governors. The Secretary General continued to provide financial, legal, and administrative support, and COMSAT provided certain technical and operational management services to INTELSAT under a contract that runs through February 11, 1979.

In May 1975 the last satellite in the Intelsat IV series was launched. It provides a capacity of about 4000 two-way voice channels plus television in the Indian Ocean Region. INTELSAT launched the first and second satellites of the new Intelsat IVA series in September and December 1975. These satellites each have a capacity of over 6000 two-way voice channels and will augment INTELSAT's capability to provide on a global basis voice, teletype, data, facsimile, and television services. Moreover in July 1975 the INTELSAT Board of Governors authorized a request for proposals covering the design, development, manufacture, and test of seven Intelsat V satellites. Through use of new techniques, these satellites are expected to have a capacity of approximately 12,000 two-way voice circuits plus television. As of September 12, 1975, there were 114 operating Earth-station antennas providing full-time service at 89 stations in 64 countries.

Maritime Satellites

For a number of years the world's maritime nations have realized that a communications satellite system might be the solution to the inadequacies of the present system of communications with and between ships at sea. To this end the U.S. participated in an international conference convened in April 1975 by the Intergovernmental Maritime Consultative Organization (IMCO) to examine the establishment of a global maritime satellite system. At that conference and several intersessional meetings afterwards, progress was made in reaching agreement on fundamental institutional and organizational principles. IMCO will reconvene the conference in February 1976.

Aeronautical Satellites

Negotiations regarding the establishment of an experimental aeronautical communications satellite system (Aerosat) culminated with the entry into force on August 2, 1974, of a Memorandum of Understanding between the Federal Aviation Administration (FAA), the European Space Research Organization (ESRO, now known as European Space Agency, ESA), and the Government of Canada. The program is designed to test the use of communications satellites for air traffic control and civil aviation purposes. ESA has selected the Communications Satellite Corporation (COMSAT), a U.S. corporation, to be co-owner with it and Canada of the space segment to be provided; COMSAT, in turn, will lease communications capabilities to the FAA. It is planned to launch two satellites in the late 1970s. These will be placed in geostationary orbit over the Atlantic Ocean. An operational system could be in place by the mid-1980s. AEROSAT

Council meetings have been held periodically in 1975.

Support of Federal Agencies

NASA Spaceflight Support

The Department and its posts overseas continued in 1975 to support NASA manned space flight missions, by arranging for the basing of recovery, tracking, and other mobile support forces at foreign installations.

Cooperation with the Department of Defense

During 1975 the Department of State continued to work closely with the Department of Defense on various military space issues having international implications.

XIV

Arms Control and Disarmament Agency

Introduction

The interest and involvement of the Arms Control and Disarmament Agency in space activities is threefold. First, ACDA is concerned with maintaining space as an environment free of military forces and weapons. Second, ACDA is interested in the use of space for the purposes of peacekeeping, crisis management, and the verification of arms control treaties. Third, ACDA seeks to ensure that other countries will not use space technology and equipment to develop strategic offensive weapons. In each of these areas, ACDA participates in the formulation of U.S. policy, in the negotiation of international agreements, and in evaluating the effect of such policies and agreements on arms control and disarmament issues.

Demilitarization

Two international treaties continue to contribute importantly to the effective demilitarization of outer space. The Limited Test Ban Treaty (Treaty Banning Nuclear Weapon Tests in the Atmosphere, in Outer Space and Under Water) prohibits nuclear weapon tests or any other nuclear explosion in outer space. The Treaty was opened for signing in 1963. As of the end of 1975, 107 countries have ratified it and 16 countries have signed but not yet ratified. The Outer Space Treaty (Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies) specifically bans the emplacement of weapons of mass destruction in Earth orbit, on celestial bodies or elsewhere in outer space, and it forbids the establishment of military bases, the conduct of military maneuvers, or the testing of weapons on celestial bodies. The Treaty was opened for signature in 1967. As of the end of 1975, 53 countries have ratified it and 35 countries have signed but not yet ratified.

Crisis Management and Verification

Preserving the use of space for peacekeeping activities such as crisis management and treaty verification is an important ACDA interest, and has been reflected in several international agreements. The 1971 Agreement on Measures to Improve the U.S.-U.S.S.R. Direct Communications Link and the technical Annex to that Agreement provided for a secure and direct "hotline" link between the U.S. and Soviet governments via space satellite for the transmission of urgent information, notifications, and requests for information in situations requiring prompt clarification. The space-based communications link, exploiting the capabilities of the Intelsat and Molniya communication satellite systems, is a significant step in our continuing effort to reduce the risk of nuclear war.

ACDA's interest in using space for monitoring compliance with the obligations imposed by arms control treaties and agreements is reflected in the provisions of the 1972 strategic arms limitation agreements with the Soviet Union. These provisions specify that each party shall use, for the purpose of monitoring treaty compliance, the national technical means of verification at its disposal in a manner consistent with generally recognized principles of international law, and that neither party shall interfere with or impede verification by national technical means.

Space Technology

Finally, ACDA is active in the formulation of U.S. policy on bilateral and multilateral international programs for the peaceful use of space. ACDA seeks to discourage other countries from using space technology and hardware for the development of strategic offensive weaponry, and it participates in the reviews that precede the export of U.S. space technology and hardware and avionics systems. ACDA seeks to institute and maintain safeguards that will minimize possible exploitation of such technology and hardware for military applications, while not curtailing legitimate trade or discouraging international cooperation.

XV Department of Transportation

Introduction

During 1975 the Department of Transportation continued to ensure the coordinated effective administration of transportation programs of the Federal government and to facilitate the development and improvement of coordinated transportation service as assigned in the Transportation Act of 1966. The major responsibility under this Act is the development of a transportation system which will provide fast, safe, efficient, and convenient low-cost transportation. Although this mandate is applied to all modes of transportation, it is especially evident in the DOT 1975 operational accomplishments and in long-term implications of aeronautics and space research and development.

Most of the aeronautics and space activity in the Department of Transportation (DOT) is managed primarily by the Federal Aviation Administration (FAA), with some participation by the other administrations. The Office of the Secretary (OST) also conducts research projects related to aeronautics and space to (1) evaluate the feasibility and desirability of alternative future systems, (2) apply advanced technology toward the solution of multimodal problems, and (3) identify and assess future R&D opportunities. Many such programs are later transferred to an operating administration for systems development, test, evaluation, and demonstration. The Transportation Systems Center, in Cambridge, conducts programs relating to aeronautics and space, such as supporting FAA on air traffic control system improvements and systems management support to both the FAA and the Coast Guard in a number of applications of satellite technology to transportation operations.

The evolving strategies of the Department's R&D program are two: (1) to place more emphasis in the short to medium term on those system developments and operational innovations which will upgrade present systems; and (2) to develop the technological building blocks to advance and extend the capabilities of the present system to meet the needs and challenges of the future. Examples of projects to "upgrade and maintain" the present system include the Upgraded Third Generation Air Traffic Control R&D, and Aviation Safety and Noise Abatement programs. "Advance and extend" programs are typified by the Advanced Air Traffic Management Systems Project, and Loran-C applications.

Office of the Secretary (OST) Programs

Several aeronautics and space related projects were initiated or continued by OST in 1975. They include the Climatic Impact Assessment Program (CIAP), Noise Abatement, Potentials of Low/Medium Density Service Improvement Satellite Applications, and Loran-C Applications.

The Climatic Impact Assessment Program

The Climatic Impact Assessment Program (CIAP) was established in the Office of the Secretary in 1971. It was a congressionally funded program that put together all the significant factors from a study of the effects of propulsion effluents of a world aircraft fleet operating in the stratosphere and determined a basis for regulatory constraints to prevent adverse environmental effects.

Accomplishments in 1975. Specific accomplishments in 1975 include:

1. Public dissemination and clarification of the CIAP Report of Findings was completed; this described specific actions for controlling stratospheric pollution and concluded that environmental danger can be avoided without prohibiting flight.

2. Initiated a continuing program in the DOT/FAA to determine the effects on the Earth's environment of high-altitude aircraft, as a part of the total environmental program carried on by FAA.

3. Compilation of the scientific backup data developed in support of the CIAP findings, according to six disciplinary areas with the following titles:

I. The Natural Stratosphere of 1974
II. Propulsion Effluents in the Stratosphere
III. The Stratosphere Perturbed by Propulsion Effluents
IV. The Natural and Radiatively Perturbed Troposphere

V. Impacts of Climatic Change on the Biosphere
VI. Economic and Social Measures of Biologic and Climatic Change

These documents contain the basic technical references to scientific knowledge which will provide universities, libraries, government laboratories, and international research organizations with a basic encyclopedia for research on the stratosphere, and will produce long term benefits as other scientific endeavors related to the stratosphere are developed in the future.

The continuing atmospheric monitoring and research program entitled "High Altitude Pollution Program" under the direction of the FAA seeks to reduce the uncertainties in current scientific data and ascertain whether atmospheric quality is being maintained, provide guidance for decisions concerning regulatory actions, and minimize the cost of providing any required environmental safeguards.

Noise Abatement

Substantial progress continued in understanding the kinds of noise associated with aircraft flight, to provide one basis for setting and regulating future noise levels. During 1975 the major R&D focus was on suppression techniques for high-velocity jet exhausts, turbojet engine core noises, and turbulent-boundary-layer aerodynamic noise, to establish realistic long-term minima, below which noise reduction may not be possible or feasible. Another vital area includes research in measurement of aircraft noise, through better understanding and calculation of atmospheric and meteorological effects on noise propagation, to ensure valid field certification measurements for regulation purposes.

Because aircraft noise reduction at the source is limited by anticipated noise "floors" for practical aircraft, the Department launched the development of a definitive long-term airport noise policy to aid airport proprietors in alleviating the residual noise impacts around their airports.

Loran-C Applications

Although developed initially as a radio navigation system for maritime use, Loran-C has potential for aeronautical and land mobile uses. During 1975, the Office of the Secretary sponsored and coordinated efforts to maximize the public benefits of existing fiscal commitments to the Coast Guard's Loran-C. Developments in technology promise continuing reduction in receiver cost, with unit prices of a few hundred dollars being confidently predicted.

Somewhat less is known about the performance of Loran-C for aeronautical and land uses than for maritime applications. Thus, research and development efforts have been initiated to learn more about Loran-C performance limits for its use on the surface and in the air.

Specific accomplishments of this DOT effort during calendar year 1975 include:

- Coordination and definition of application-oriented research and development efforts in FAA, Federal Highway Administration, National Highway Traffic Safety Administration, Coast Guard, and Urban Mass Transportation Administration.
- Designation of the Assistant Secretary for Systems Development and Technology to coordinate the Loran-C efforts.
- A study of technical requirements for terrestrial navigation.
- Conceptual definition and functional description of emergency vehicle uses of Loran-C.
- Support of development by the Coast Guard of a sophisticated aircraft Loran-C navigation unit holding promise for Coast Guard applications, with potential for civil air use.
- Initiation of a project to evaluate the application of Loran-C for non-precision approaches to airports and area navigation in mountainous regions.

FAA Research and Development: Aviation Safety

FAA research and development programs designed to promote aviation safety can be conveniently divided into three categories: (1) airport safety; (2) enroute safety; (3) aircraft security. The most significant calendar year 1975 efforts in these categories follow.

Airport and Vicinity

Microwave Landing System (MLS). An element of the Upgraded Third Generation ATC System is the Microwave Landing System. The prototype Microwave System is designed to meet the needs of all aircraft, both civil and military, and should have the modularity and flexibility to serve sites that cannot be accommodated by the present Instrument Landing System (ILS) over the full range of weather conditions and traffic densities.

Phase I, technique analysis and contract definition, was completed in 1973. Phase II, feasibility demonstration, included the dynamics and flight test of four feasibility models at the National Aviation Facilities Experimental Center (NAFEC) in Atlantic City, New Jersey, and at Wallops Island, Virginia, was completed in June 1975. Phase III, prototype development and evaluation, was begun in July 1975. This system is being entered in the international competition being sponsored by the International Civil Aviation Organization to select a worldwide, standard Approach and Landing System.

Minimum Safe Altitude Warning. Minimum Safe Altitude Warning (MSAW) is provided through a computer program residing in the terminal air traffic control automation system. MSAW alerts the air traffic controller if an aircraft under his control is, or could in the immediate future be, too low for safe operation. The program was demonstrated at NAFEC and was then submitted to field evaluation at the Denver Stapleton Air Terminal Facility. Following a successful field evaluation, the decision was made to implement MSAW nationally. Implementation is expected to be completed by the end of calendar year 1976.

Aircraft Security. FAA engaged in the following activities, among others, in its continuing effort to deter aircraft sabotage and hijacking and other overt acts against aircraft.

- Completed the installation and began assessing the potential of X-ray absorption to detect explosives in hand-carried and checked baggage.
- Assessed new techniques for detecting vapors from explosives in baggage or carried by people.

Other Terminal Area Safety Developments. FAA pursued a variety of other programs designed to improve performance and enhance safety in and around airports. These efforts included:

- Conducting tests under an interagency agreement with the U.S. Navy to determine whether configurations or methods costing less than the present runway grooves can be used as a means of minimizing hydroplaning on wet surfaces.
- Issuing a series of technical reports on airport pavement design, including: (1) non-destructive vibrating testing of airport pavements, (2) a survey and analysis of aircraft traffic showing that pavement edge sections can be reduced in thickness, (3) a study of aircraft-pavement compatibility demonstrating how to operate on rougher pavement, (4) statistical quality control of pavement materials to reduce costs, (5) faster ways of measuring pavement profiles to detect failures or incipient failures.
- Completing a study which shows that solar energy may be a method of controlling snow and ice on selected portions of airport pavement.
- Developing a support structure for approach lights that would collapse and do minimum damage to aircraft in cases of accidental impact.
- Designing a lighted wind-cone for installation at the end of runways to provide better wind-cone visibility.
- Completing a survey of the electrostatic charging tendency of fuel delivered at 10 major airports. This survey was part of an FAA-industry program to prevent explosions from electrostatic discharges during aircraft fueling.
- Completing an in-house engineering study which showed that a thermal, ground-based system for dispersing fog at Los Angeles International Airport could be cost-effective and outlining the design for such a system.

En Route and Post-Crash Safety

FAA's calendar year 1975 research and development efforts to reduce or eliminate hazards incident to en route operations and increase the chance of survival in the event of an accident included a number of activities:

- Exposing small animals to toxic gases to establish a relative hazard scale, based on time-to-incapacitation, that can be associated with the ability of humans to evacuate an aircraft.
- Determining the fire hazard of various flight attendant uniforms.
- Continuing development of a technique to analyze crashworthiness by finite element.
- Investigating methods of preventing stall/spin accidents through better training.
- Developing criteria for aircraft design and certification looking to the avoidance of unintentional stalls.
- Beginning a cooperative FAA/Canadian testing program using airborne simulation to determine effect of wind shear and heavy turbulence on landing aircraft.
- Determining the least dangerous location in aircraft in which to place explosives discovered during flight.
- Initiating an effort to determine the role of detectors, extinguishants, and compartmentation in reducing post-crash and in-flight fire hazards.
- Developing data that establish the characteristics, capabilities, and effectiveness of ground trainers used in training pilots in specific maneuvers.
- Completing the testing of a propeller-vibration measuring technique for general-aviation aircraft to provide data for propeller certification standards.
- Evaluating three airborne collision avoidance systems (ACAS) to demonstrate the technical acceptability of each approach.

Air Traffic Control and Navigation

FAA is charged with ensuring the efficient and equitable use of airspace and maintaining a common air traffic control system for both civil and military aircraft. These functions require the application of the most promising developments of a rapidly evolving technology.

National Airspace System Modernization

The primary focus of FAA's efforts to modernize the National Airspace System over the last 10 years has been the introduction of two semi-automated air traffic control systems: NAS En Route Stage A at the 20 air route traffic control centers (ARTCCs) in the contiguous 48 states and Automated Radar Terminal System (ARTS III) at 61 of the nation's busiest terminal areas.

At the beginning of calendar 1975, all 20 ARTCCs had an operational capability in automatic flight data processing and interfacility data transfer, plus computer updating equipment which facilitates communications between the controller and the automated system. In addition, 14 of the 20 ARTCCs were fully commissioned with digital radar displays and radar data processing. In 1975, the remaining six ARTCCs became operational with digital radar displays and radar data processing; the 20th center was fully commissioned in August 1975. The initial phase of implementation for the terminal automation program was concluded this calendar year with the 61st ARTS III also becoming operational in August 1975.

FAA plans to provide approximately half of the high-density terminal facilities with primary tracking, continuous data recording, multiprocessing, and failsoft capability. The research and development effort for these additions to the ARTS III system was completed in August 1973.

FAA also plans to introduce a less complex automation system—ARTS II—at 70 lower-density terminal radar control facilities. Delivery of the first system is planned for October 1975, with the last system scheduled to be delivered in mid-1978.

Aeronautical Satellite Program. The United States, Canada, and the European Space Agency (ESA) initiated the joint Aeronautical Satellite (AEROSAT) program to provide two satellites in geostationary orbit over the Atlantic Ocean for experimentation and evaluation of improved oceanic air traffic control and communication systems characterized by high quality voice and data transmission as well as dependent and independent surveillance. Specifications were completed for the satellite system and requests for proposals for development of the system were issued by ESA and the U.S. common carrier (COMSAT General Corp.). FAA will lease satellite channels from the U.S. common carrier.

Flight Service Station Program. On July 24, 1975, the FAA inaugurated a year-long test and evaluation of a semi-automated flight service station at its Atlanta, Georgia, facility. The installation uses computer-based equipment that presents selected weather and aeronautical information directly to the flight service specialist assisting the pilot. Improving the speed and efficiency of service to pilots is a major step in the planned flight service station program to meet tomorrow's needs in the airspace system. Plans have been announced for the test and evaluation of a prototype automated flight service station at Leesburg, Virginia, which will be co-located with the Washington ARTCC, as the next step in modernizing the flight service station system. The plan calls for applying modern technology in data processing and distribution in achieving a more effective operation than today's highly labor-intensive system.

Area Navigation (RNAV). FAA is focusing on issues that needed resolution to permit FAA and users to decide on procedures, timing, and the extent to which area navigation (RNAV) would be implemented in the National Airspace System (NAS). The year-end results show that implementation of RNAV, based on recommended modifications to the RNAV Task Force concepts, could be expected to provide substantial benefits to the airspace user and the ATC system.

Major user payoffs would result from fuel and flight time savings due to en route and terminal area mileage reductions, optimized descent corridors, and increased airport capacity. In addition, safety would be increased by elimination of circling approaches and providing more conflict-free departure and arrival procedures. Highlights of savings to the ATC system include the following: reduction in controller vectoring and communication contacts and talk time, potential increase in controller productivity, no decrease in terminal capacity during the initial transition period (RNAV/vector mix), en route and terminal capacity increases, and reduction in the number of VORTACs with a corresponding reduction in maintenance costs.

Other Developments. In addition to the foregoing, FAA

- Completed its testing of the anti-midair collision capability of Synchro-DABS. This equipment, used in conjunction with the DABS/IPC system, could provide aircraft with an onboard capability for collision detection and warning at a minimum added cost. Aircraft equipped with Synchro-DABS would be able to detect and avoid all aircraft carrying a DABS transponder, even if DABS ground-system (surveillance) coverage were unavailable. Synchro-DABS experimental equipment was built by the DOT Transportation Systems Center in Cambridge, Massachusetts. Testing began at the Naval Weapons Center, China Lake, California, in late 1974.
- Developed a field modification kit to improve the reliability and performance of the agency's Airport Surface Detection Equipment (ASDE-2) radars. The first of two kit modifications was installed at 11 facilities to improve and activate the ASDE-2s at those sites. In addition to improving performance, the modifications improve reliability and reduce maintenance requirements.
- Developed and installed for evaluation at the John F. Kennedy International Airport a new

BRITE display for use with ASDEs. The display makes possible better viewing of targets, even under the brightest lighting. On the basis of these tests, the new BRITE displays have been ordered for installation and use at JFK, Chicago O'Hare, and San Francisco.

- Significantly expanded the FAA's program to eliminate, to the extent practicable, the effects of wind shear on approach/landing and takeoff of aircraft. Successful tests of ground-based remote sensing systems to measure wind shear were initiated at Denver, Boston, and New York airports. Plans were announced for early tests in 1976 of a ground-based sensing system at Dulles International Airport and an accelerated test program at O'Hare Airport to provide data on wind shear phenomena associated with the gust fronts of thunderstorms. Simulation facilities are being used to develop techniques to help train pilots in handling aircraft during wind shear occurrences.

- Reduced the channel spacing of VHF air/ground communications by half, thereby approximately doubling the number of channels available. FAA will continue making assignments on 50 kHz unless frequency congestion necessitates use of 25 kHz.

- Using an inertial navigation system in its KC-135 aircraft, demonstrated and tested a satellite-supported oceanic ATC communications and surveillance system. The satellite used in the experiment was NASA's Applications Technology Satellite 6, an experimental unmanned spacecraft designed for the conduct of meteorological, communications, scientific, and technological experiments.

- Completed development and specification of an initial National Airspace Data Interchange Network system capability. This is expected to modernize FAA's data communications network for domestic flight movement information, providing increased data transfer and a faster response time. It is one part of the Integrated National Airspace Communications System, which will integrate all FAA-operated voice and data communication subsystems. Cost savings and operating efficiencies are expected from this system approach.

- Began an operational evaluation of automated conflict alert for the en route system at the Kansas City ARTCC in February 1975. The conflict alert software operates initially for air traffic at high altitudes (7300 meters and above). The computer projects ahead from the aircraft's current position for about two minutes to detect any potential conflicts and indicates the aircraft involved directly the controller's radar scope. An additional display, identifying the aircraft, would also appear on one side of the scope, thereby further facilitating controller analysis of the situation. Nationwide implementation was completed in 1975.

- Undertook a study of air navigation requirements for Alaska. The unique environmental problems of Alaska have in the past posed difficulties in selecting a cost-effective navigation system.

- Continued work to define a system for integrating weather data into the National Airspace System. The objective was the automatic transmission and display of weather data at appropriate ATC facilities.

XVI The Smithsonian Institution

Introduction

The Smithsonian Institution contributes directly to this nation's aeronautics and space programs through the activities of the Smithsonian Astrophysical Observatory and the National Air and Space Museum.

During the past year, Smithsonian observers and research scientists used space techniques to gather data pertinent to geophysical and astrophysical research. Smithsonian experiments aboard high-altitude balloons and satellites measured radiation from distant energy sources screened from ground stations by the Earth's atmosphere. Smithsonian laboratories analyzed both returned lunar samples and recovered meteorite specimens for new clues to the mystery of lunar and planetary evolution. And while Smithsonian laboratories and field stations increased man's knowledge about the universe, its museums diffused and disseminated this knowledge to the public through exhibits, displays, and special programs.

Smithsonian Astrophysical Observatory

Since 1973, the related research activities of the Smithsonian Astrophysical Observatory and the Harvard College Observatory have been coordinated under a single director. This cooperative venture combines the facilities of both observatories in a Center for Astrophysics at Cambridge, Massachusetts. The consolidated science program draws on the resources of both Harvard University and the Smithsonian Institution and engages more than 120 scientists in a broad program of research encompassing most current interests in astronomy and including several programs in direct support of national space goals.

Geoastronomy

The Observatory operates a worldwide network of tracking stations to observe precise positions of artificial satellites (using optical telescopes and laser ranging) and employs the resulting data to extract information about the Earth's shape, gravitational field, and upper atmosphere.

The French Starlette satellite, orbited in March 1975, and the Geos 3 satellite, launched in April 1975, are among the dozen satellites now being tracked. Radar altimeter data from the latter satellite will be analyzed to determine the ocean geoid. The Observatory is also coordinating all international use of the Geos 3.

Lageos, a satellite conceived by the Center, is expected to be launched in February 1976. Using laser ranging to its corner reflectors, it is hoped that 2-centimeter range accuracy can be achieved. The data from such precise tracking will be used as part of NASA's Earth and Ocean Physics Application Program, with a primary objective the definition of an operational Earthquake Hazard Assessment and Alleviation model and system by 1983. Secondary objectives are the refining of the global geoid model and establishment of the mean sea-surface topography. The program includes an integrated and balanced effort composed of several other activities, with emphasis on global plate tectonics, the global geoid, tides, tidal loading, postglacial rebound, rotation of the Earth, and formulation and evaluation of earthquake hazard assessment models.

The Observatory has prepared an extremely precise hydrogen maser clock for flight to check Einstein's prediction that such a clock will "tick" faster than an identical clock on Earth. This prediction, fundamental to the theory of relativity, has so far been verified at the one-percent level; this experiment should be one hundred times more accurate.

An experiment was flown aboard the joint U.S.-U.S.S.R. Apollo-Soyuz Test Project in July 1975. This experiment attempted to measure gravitational anomolies in the Earth by extremely precise monitoring of the distances between the U.S. and Soviet spacecraft.

The 20-year Moonwatch program involving an international network of volunteer visual satellite observers was disbanded at the end of June 1975. Since the first observations of Sputnik I in 1957, the network has made approximately 400,000 observations of artificial satellites in support of the space program.

High-Energy Astrophysics

A major program of X-ray astronomy, using rocket and satellite-borne detectors, has discovered many stellar X-ray sources, which appear to be associated with collapsed stars (white dwarfs, neutron stars, or, in two cases, black holes) orbiting normal stellar companions. Extragalactic sources were also found, including many clusters of galaxies.

An experiment aboard the Astronomical Netherlands Satellite detected increased X-ray activity in the object Cygnus X-1 between May 1 and May 5. This sparked a series of ground-based searches leading to detection of increased radio emissions by astronomers at the National Radio Astronomy Observatory. The corresponding activity in two wavelengths confirms observations of dual intensity changes from Cygnus X-1 first seen four years earlier, supporting the contention that the object is a black hole and suggesting physical mechanisms unique to such stellar systems.

The continuing X-ray program includes participation in the series of High-Energy Astronomy Observatories (HEAO) designed for flight before the end of this decade, with major effort going into the design of a large X-ray telescope on HEAO-B, which will have a resolution better than 2 arc-seconds.

Lunar and Planetary Sciences

Several research programs involving lunar and meteorite samples are continuing, including mineralogical and petrological studies on a complex brecchia boulder from the Apollo 17 site and on particles from the Allende carbonaceous chondrite, as well as isotopic investigation of lunar material. In a related program, inexpensive detectors have been developed to determine the neutrino fluxes from various cosmic sources. The Prairie Network, a 10-year project to photograph bright meteors (fireballs) and to recover any resultant meteorites, is being discontinued.

Solar and Stellar Physics

Smithsonian scientists associated with the Harvard Solar Satellite Project are deeply involved in the analysis of the solar ultraviolet data gathered by Skylab. All the evidence points to strong magnetic control of the chromosphere and corona, demonstrated by prominent arch structures and bright points. Recent work has developed evidence for wave propagation from lower to upper layers; if expectations are fulfilled, the long-sought heating mechanism for the corona will be found.

The ultraviolet data have been complemented by X-ray observations from the same spacecraft. Among the more striking findings is confirmation of the fact that "coronal holes," regions where the coronal density and temperature are low, appear to be the source of streams of solar wind. Further work concerns the high densities and temperatures along magnetic coronal arches. This work will lead to a better understanding of the solar corona and how the solar wind originates in it.

Stellar research was carried out using orbiting ultraviolet telescopes aboard the satellite Copernicus. A recent finding is that Capella, a nearby star of solar type, may have a stellar wind.

National Air and Space Museum

Flight Experiments

The Center for Earth and Planetary Studies coordinated the "Earth Observations and Photography" experiment on the Apollo-Soyuz mission, including the preflight training of the astronauts, planning of tasks, and the real-time science support during the mission. Support operations included coordination of research by ground-truth parties from NOAA and numerous academic and research organizations, including the Smithsonian's own Center for Short-Lived Phenomena, and the relay of information to the Apollo-Soyuz astronauts. Analysis of the acquired photographs and the verbal comments of the astronauts are being coordinated with experts in geology, oceanography, desert study, hydrology and snow mapping, meteorology, and environmental science.

In related research, a desert study has been initiated to assign relative ages to desert regions based on their color as it appears on orbital photographs. Oxidation of iron makes older deserts appear redder than younger sands. It seems feasible to identify from space photos areas of young sand movements in drought zones. This study is being coordinated with ground-truth data collection in the part of the Western Desert of Egypt photographed by Apollo-Soyuz.

Lunar Research

Lunar research at the Center for Earth and Planetary Studies emphasized the synthesis of Apollo data, particularly the correlation of photogeological, geophysical, and geochemical data. The results of these correlations were published in two papers: "Surface Geology of the Moon" and "The Moon after Apollo." In an effort to map and classify features other than craters on the Moon, maps were made of the long linear depressions called *Rimae*, and a map of the sinuous elevations called *Dorsa* is in progress. An atlas of lunar surface features as viewed by Apollo orbiting spacecraft was completed for publication by NASA.

Center personnel also participated in activities related to the nomenclature of features on the Moon and planets through membership in the Task Group for Lunar Nomenclature of the International Astronomical Union, the Nomenclature Group of the Lunar Photographic and Cartographic Committee, and the Advisory Committee on Extraterrestrial Features of the Board of Geographic Names.

Exhibits

In preparation for the opening of the new National Air and Space Museum on July 4, 1976, an "Apollo to the Moon" exhibit is being completed. This exhibit will convey the story of Apollo in a novel and interesting way and will include summaries of current lunar science centered on the displays of four lunar samples. At the new museum, the public will be able to touch one of the lunar rocks on display.

XVII United States Information Agency

Introduction

The United States Information Agency (USIA) is in the Executive Branch of Government, with posts, known as the U.S. Information Service (USIS), in 111 countries on six continents, and with press, radio, TV, and film facilities. In addition there are 247 information centers, reading rooms, and libraries abroad with over nine million visitors annually. The Agency's mission is to support U.S. national interests by conveying an understanding of the United States as a nation and as a people; by explaining national policies and the reasons for them, and by advising the government on the implications of foreign opinion for the formulation and implementation of foreign policy. USIA provides liaison between U.S. and foreign universities, and administers abroad the Cultural and Educational Exchange program of the Department of State. Officers serving in posts abroad provide a person-to-person link with local opinion leaders and promote contact between American and local experts. In this mission space and aeronautics are of prime importance, crossing oceans and land barriers, and leading to bi-national and multi-national cooperation and understanding.

1975 was a most successful year, particularly with NASA's efforts in the first bi-national docking in space (Apollo-Soyuz), the first satellite TV broadcasts by the government of India (SITE), and the development of international interest in the Earth Resources satellites (Landsat). Foreign correspondent facilities were extended to 12 countries for reports on subjects ranging from satellite weather forecasting (Turkey) to the economics of space spin-offs (Switzerland). In the Apollo-Soyuz Test Project the Agency assisted the coverage of many of the 151 foreign correspondents at the Kennedy Space Center, and 205 at the Johnson Space Center. Analysis of foreign media showed extensive coverage of the event with banner headlines second only to the launch of Sputnik or the U.S. landing on the Moon.

Radio

USIA's Voice of America operates 113 transmitters for a total of 775 hours per week in 35 languages. During 1975 aeronautical and space events were covered daily and hourly in regular newscasts, and approximately 350 additional hours were filled with balanced and in-depth coverage of U.S. space developments. These reports featured Mariner, Pioneer, the two Viking probes to Mars, and the Helios satellite for solar research launched as a cooperative venture by the U.S. and the Federal Republic of Germany. The Apollo-Soyuz story began with the planning stages, and carried through the two launches, docking, splash-down, and the tours of the joint ASTP crew. Indicative of the weekly international audience of an estimated 50 million, a radio offer of Apollo-Soyuz souvenir postcards was responded to by thousands of listeners, many of whom were in the Soviet sector. The sixth anniversary of Armstrong's first step on the Moon was used as an opportunity to review the significance and achievements of the entire Apollo program.

The Voice of America emphasized the growing use of space technology by other countries, such as the new European Space Agency, the U.S. launching of the Franco-German communications satellite Symphonie 2, and Bangladesh's entry into the Satellite Age. Among the more than 1100 features and reports were many that highlighted the spin-off benefits for mankind in medicine, communications, agriculture, weather forecasting, mineral exploration, and education. Among these features VOA's Burmese Service carried an interview of an official of Comsat Corporation with an account of Indonesia's use of satellites and the possible interest to Burma, and the Hindi Service described the SITE broadcasts of TV to the villages as a demonstration of U.S. interest in the welfare of the Indian people. The Landsat satellite system was explained for its value in helping to locate the right land to cultivate, the danger areas threatened by crop disease and drought, and the potential reserves of water, oil, and mineral resources so needed for development. The capability of this system was covered effectively in the Spanish, Hindi, Bengali, and English-to-Africa language services.

Press and Publications

Developments in space exploration and technology continued to be used in the printed media in line with the Agency's mission. Foreign press coverage in text and pictures of NASA's launches and deep-space experiments is often based on material transmitted to USIS posts by radio-teletype known as the Agency Wireless File, and by illustrated information packages on current events. Magazines are circulated regularly in 31 principal languages, carrying survey articles on topics of significance to the U.S. by staff and internationally recognized guest writers. The editorial policy is based on the separate requirements of five geographical areas, with attention to requests from USIS posts for local needs in news and general subject matters.

The immediate reporting over the Wireless File of aeronautical and space technology is best illustrated by some sample headlines—U.S. orbits second Earth Resources satellite—Mariner 10 verifies Mercury's magnetic field—Report describes effect of aircraft on ozone in stratosphere—ATS-6 readied for international experiments—Apollo astronauts conducting Earth studies around globe—the global electronic village—Doctor in the sky—Dam-building along Parana-Paraguay rivers assisted by Apollo-Soyuz data collecting.

Comprehensive stories were provided at the specific request of country posts on such topics as an African seminar on Landsat, the AID report on the development of the Sahel, an article for the Soviet magazine *Technology and Youth* on Apollo-Soyuz, and a comprehensive series of articles on "What we have learned from space."

Horizons USA, a bimonthly illustrated magazine in English, Spanish, and 12 other languages gave a preview of the Apollo-Soyuz mission and also an article on "Unsolved Mysteries in Space."

America Illustrated, the USIA monthly magazine in Russian, distributed in the U.S.S.R., covered Skylab I, Apollo-Soyuz, human interest stories on the astronauts and space artists, and a special article examining the far-reaching space explorations made over the years by Americans and Soviets. *Topic* magazine, published in French and English for sub-Sahara Africa, ran stories on Robert McCall, the space artist; educational satellites; and a special article on the meaning of space flight to mankind. *Dialogue*, an intellectual eight-language quarterly, discussed the scientific understanding of the Moon's structure.

The Agency also produced eight magazines at major overseas posts and these used features on space obtained by the Special Projects Office, Washington, D.C. Tehran printed an article on satellite weather photography provided by Kodak and other sources, Jakarta used an article from Bell Aerospace; Hong Kong used "ATS, first teacher in space" from Martin Marietta. General-interest articles printed were by James Fletcher, Administrator of NASA; Wernher von Braun; Henry Simmons; Michael Collins, Director of the National Air and Space Museum; Isaac Asimov; Allen Hammond; Richard Lewis; and other well-known persons.

Films and Television

The television studios of the Agency produced video tape recordings (VTR) for showing on closed-circuit TV to selected audiences in USIS posts and TV networks in more than 100 countries. These items are in English and the principal foreign languages. In addition documentary films suitable to the Agency mission are acquired or produced under contract for showing on TV and in commercial cinema theaters abroad. Newsclips of current events in the U.S. are provided to foreign TV stations and many of these are transmitted via satellite relay. Foreign TV teams are assisted in the U.S. on assignments which include aeronautics and space, and the Washington studies of USIA are made available to them. The potential world audience is 100 million for film and 800 million for TV.

Recognizing the impact of vision-plus-sound, USIA further increased the already successful TV programming in 1975. A news service with a Washington correspondent was established this year for seven selected USIS posts. The subject matter included weather satellites, Apollo-Soyuz, and the Viking mission to Mars. "Laporan Dari Amerika," a monthly TV series for Indonesia, gave a history of communications satellites and a review of the forthcoming launch of Indonesia's own communication and educational satellite, due in 1976. "Vision," a monthly review televised in more than 60 countries, had a feature on the Westar satellite of the Western Union Co. "Science Report", which issues two, wide-audience magazine programs each month, carried the highlights of space science in 1975. Produced in English, Spanish, Portuguese, French, Arabic, and in a non-verbal music-and-sound-effects version that can be adapted with script at the local station, "Science Report" is regularly telecast in some 80 countries. 1975 topics included Apollo-Soyuz, the Pioneer probe to Jupiter, Mariner's fly-by of comet Kohoutek on the way to Venus and Mercury, and Helios.

Full-length USIA-produced documentaries included "The Age of Man in Space," which was a prelude to Apollo-Soyuz, and "The Tiny World," a dramatic introduction to the technology of miniaturization as it applies to satellites such as ATS-6. The latter film was edited and made into a 35mm version which was used in cinema circuits in more than 50 countries.

The very effective VTR system was used increasingly in 1975 for closed-circuit showing in USIS posts and in program slots on foreign TV networks. Two special programs were made using and explaining Landsat images of California, Washington state, and West Africa. A set of four VTRs was made covering the future of space, and these were shown in total or in part at more than 150 posts. TV stations also use slides to illustrate news events in the U.S., and a package of 87 space and aeronautics pictures was distributed to more than 100 foreign stations. The set included the Space Shuttle, Kennedy and Johnson Space Centers, a deep-space view of the whole Earth, and similar subjects.

Newsclips were distributed for multinational television usage on many space topics, including the launching of Apollo, the ATS educational satellite positioned for use by India, and the visit of astronauts Stafford, Slayton, and Brand with President Ford at the White House. The latter item received worldwide coverage.

Satellite transmissions of events in the U.S. were supplied on request to Israel, Jordan, Latin America, Senegal, and the U.K. The film of the Cerro Tololo Observatory, funded by NSF, was offered to Europe, the Middle East, Asia, and Latin America. Other material and excerpts were supplied on request.

The Agency facilitated the loan of NASA and other U.S. government films abroad; it certified educational, scientific, and cultural audio-visual material of U.S. origin for export; and was instrumental in the selection and entry of NASA and USIA films and TV productions in exhibitions and international film festivals. USIA's "Age of Man in Space" was accepted at exhibitions in Australia, New Zealand, Lebanon, and Italy.

Information Centers and Exhibits

The 247 information centers of the Agency provide direct contact between U.S. experts and the corresponding specialists and officials of the host countries. In-depth seminars and conferences can be arranged, with augmentation by closed circuit TV, films, exhibits, and demonstration equipment.

A seminar on remote sensing from satellites was arranged for African nations with a presentation in English in Accra, Ghana, and in French in Bamako, Mali. Fifty experts on natural resources from nine African nations discussed in Bamako the full utilization of the Landsat receiving station scheduled for completion in Kinshasa, Zaire, in late 1975. The U.S. ambassador to Mali praised resource satellites as "prime examples of the kind of benefits and cooperation envisioned by the drafters of the U.N. treaty on the Peaceful Uses of Outer Space." The Mali Minister of Development called the conference an "indisputable and veritable success." The seminar was repeated with equal success at Accra with 100 African specialists from five nations in attendance. Following the seminars there was a lecture tour through Ghana, Ethiopia, Tanzania, and three cities in Nigeria on the social impact of space, science, and technology.

USIA participated in a nine-day satellite communications seminar in Indonesia in July 1975, preparatory to the launching of that nation's satellite. In connection with the seminar, the five U.S. participants gave lectures at universities and demonstrated educational methods using landline, short-wave radio, and satellite channels. The "Communications for Education" seminar was also given in Singapore, Malaysia, and Korea.

Approximately 50 exhibits were produced and circulated through USIS posts in 1975 and three of these were devoted to aeronautics and space. "Satellites—Servants from the Sky" was a major exhibit with the underlying theme of the importance of a free flow of satellite information. A live demonstration was engineered, with visitor participation in communicating via ATS-6. This showing was part of the Third International Space Research Exhibition in Belgrade, September 6-14, 1975, covering communications, meteorology, and the Landsat system. It was scheduled for later showing in two other Yugoslav cities. Two exhibitions with the title "Treasures of Space" were produced and toured Latin America and Africa. The theme was on U.S. technological achievements in space exploration, and the application of acquired knowledge to the benefit of the world population. Lunar samples, other space artifacts, and models of space vehicles were in the exhibition. The Moon rock samples were also shown separately in The Hague, Singapore, Cairo, Dakar, and other cities. The number of visitors to USIA space exhibits in 1975 was more than 1.5 million, including high-ranking government officials and scientists.

Appendixes

APPENDIX A-1

U.S. Spacecraft Record

Year	Earth orbit Success	Earth orbit Failure	Earth escape Success	Earth escape Failure
1957	0	1	0	0
1958	5	8	0	4
1959	9	9	1	2
1960	16	12	1	2
1961	35	12	0	2
1962	55	12	4	1
1963	62	11	0	0
1964	69	8	4	0
1965	93	7	4	1
1966	94	12	7	1
1967	78	4	10	0
1968	61	15	3	0
1969	58	1	8	1
1970	36	1	3	0
1971	45	2	8	1
1972	33	2	8	0
1973	23	2	3	0
1974	27	2	1	0
1975	28	3	2	0
Total	827	124	67	15

This earth escape failure did attain earth orbit and therefore is included in the earth-orbit success totals.

NOTES: The criterion of success or failure used is the attainment of earth orbit or earth escape rather than a judgment of mission success.

This tabulation includes spacecraft from cooperating countries which were launched by U.S. launch vehicles.

"ESCAPE" flights include all that were intended to go to at least an altitude equal to lunar distance from Earth.

APPENDIX A-2

World Record of Space Launchings Successful in Attaining Earth Orbit or Beyond

Year	United States	U.S.S.R.	France	Italy	Japan	Chinese Peoples Republic	Australia	United Kingdom
1957		2						
1958	5	1						
1959	10	3						
1960	16	3						
1961	29	6						
1962	52	20						
1963	38	17						
1964	57	30						
1965	63	48	1					
1966	73	44	1					
1967	57	66	2	1			1	
1968	45	74						
1969	40	70						
1970	28	81	2	1	1	1		
1971	30	83	1	2	2	1		1
1972	30	74		1	1			
1973	23	86						
1974	22	81		2	1			
1975	27	89	3	1	2	3		
Total	645	878	10	8	7	5	1	1

Includes foreign launchings of U.S. spacecraft.

NOTE: This tabulation enumerates launchings rather than spacecraft. Some launches did successfully orbit multiple spacecraft.

APPENDIX A-3

Successful U.S. Launches—1975

Launch date (G.m.t.) Spacecraft name Cospar designation Launch vehicle	Spacecraft data	Apogee and perigee (kilometers) Period (minutes) Inclination to equator (degrees)	Remarks
Jan. 22 Landsat 2 4A Thorad-Delta	Objective: To acquire sufficient multispectral imagery over the U.S. and foreign countries to improve remote sensing interpretive techniques and to further demonstrate the practical applications of Landsat type data. Spacecraft: Basic structure and design similar to Nimbus satellites. 3.04-m high and 1.52-m diameter, 3.96-m with solar panels extended. Spacecraft consists of three major sections: 1.4-m torus ring forms base; smaller hexagon-shaped housing, connected to ring by truss, houses attitude stabilization and control systems; two 0.9-m by 1.5-m canted solar panels. Active 3-axis stabilization. Carries a four-channel multispectral scanner subsystem (MSS), a three-camera return beam vidicon (RBV) camera subsystem, a data collection subsystem (DCS), two wideband video tape recorders (WBVTR), and a commandable orbit-adjust motor. Weight: 953 kg.	917 907 103.2 99.0	Launched successfully into circular, near-polar sun-synchronous orbit, spacecraft is companion to ERTS-1, launched in 1972. Provides contiguous images of earth once every 18 days which assist in managing earth's natural resources and protecting its environment. Data used by more than 40 states and over 40 foreign countries.
Feb. 6 SMS-2 11A Thorad-Delta	Objective: To launch spacecraft into a synchronous orbit of sufficient accuracy to enable the spacecraft to accomplish its operational requirements, conduct an in-orbit evaluation and checkout of the spacecraft and, upon completion of this evaluation, turn the operational control of the spacecraft over to NOAA/NESS, to provide the regular and useful daytime and nighttime meteorological observations in support of the national operational meteorological satellite system. Spacecraft: Cylindrical 190.5-cm in diameter and 344-cm long from the top of the magnetometer to the bottom of the apogee boost motor. TE-364-4 apogee motor measures 90-cm high and is ejected after synchronous orbit is attained. Thrust tube located in center supports radiometer/telescope instrument. Scanning mirror looks out through an opening in cylindrical solar array whose panels cover outer walls of spacecraft. Instrumentation consists of a visible infrared spin scan radiometer (VISSR) to provide high quality day/night cloud cover data and to measure radiance temperatures of the earth/atmosphere system, a meteorological data collection and transmission system, and a space environmental monitor (SEM) system to measure proton, electron, and solar x-ray fluxes and magnetic fields. Spin stabilized. Weight at launch: 628 kg. Weight in orbit: 272 kg.	35,800 35,780 1436.3 1.0	Second of a series of two operational prototypes developed and funded by NASA to meet the requirements of the Department of Commerce GOES (Geostationary Operational Environmental Satellite) system. After successful launch into transfer orbit by NASA, apogee boost motor was fired Feb. 7 and spacecraft placed in synchronous orbit at 115° west longitude. Spacecraft turned over to NOAA Mar. 10 and was placed at 135° west longitude (south of Alaska). In conjunction with SMS-1, was used for 24-hr coverage of Western Hemisphere, providing cloud cover pictures every 30 minutes to NOAA. To be used with Goes 1 in future operational system.
Mar. 10 Defense 17A Titan IIIB-Agena	Objective: Development of space flight techniques and technology. Spacecraft: Not announced.	39,338 295 702 63.5	Still in orbit.

Successful U.S. Launches—1975

Launch date (G.m.t.) Spacecraft name Cospar designation Launch vehicle	Spacecraft data	Apogee and perigee (kilometers) Period (minutes) Inclination to equator (degrees)	Remarks
Apr. 9 Geos 3 27A Thorad-Delta	Objective: To perform an in-orbit satellite radar altimeter experiment to demonstrate the feasibility and utility of mapping the geometry of the sea surface and measuring wave height; to support the calibration and position determination of NASA and other agency C-band radar systems; to perform a satellite-to-satellite tracking experiment with ATS-6 using an S-band transponder system. Spacecraft: 132-cm wide octahedron topped by a truncated pyramid for overall height of 81-cm. Eight trusses attached to 45.8-cm center tube support 16 solar cell panels. Gravity-gradient stabilization scissors boom assembly with an end mass of 45-kg is mounted in center tube near pyramid end and extends to 6.5-m in orbit. Subsystems include: radar altimeter, coherent C-band transponder, S-band instrumentation for satellite-to-satellite experiments, laser retro-reflectors, doppler transmitters, non-coherent C-band transponder, and S-band instrumentation for earth tracking experiments. Weight: 340 kg.	848 839 101.7 114.9	Geodynamics Experimental Ocean Satellite launched by NASA into circular orbit. Successfully demonstrated the feasibility and the utility of satellite altimeters for measuring precisely the geometry of the oceans and for mapping the topography of ocean surfaces. Also provided excellent results for land and ice tracking. Conducted successful satellite-to-satellite tracking experiment with ATS-6. Will contribute to fulfilling the oceanographic, geodetic, and radar calibration requirements of NASA and other agencies. Will continue to conduct localized and unique experiments for the duration of mission lifetime.
Apr. 18 Defense 32A Titan IIIB-Agena	Objective: Development of space flight techniques and technology. Spacecraft: Not announced.	398 133 89.8 110.5	Decayed June 5, 1975.
May 7 Explorer 53 (SAS) 37A Scout	Objective: To measure the x-ray emission of discrete extragalactic sources; to monitor the intensity and spectra of galactic x-ray sources from 1.0 kEV to 50 kEV and to monitor the x-ray intensity of Sco X-1. Spacecraft: Two sections, a four instrument x-ray experiment package atop a spacecraft control section, measure 145.2-cm high. Four foldable solar panels extend from control section in orbit and measure 470.3-cm tip-to-tip. Double deck aluminum honeycomb control section contains rechargeable nickel-cadmium battery; redundant tape recorders; redundant command receivers and decoders; telemetry system; redundant VHF transmitters; magnetometers, Sun sensors, and a star sensor; and a magnetically torqued commandable control system. Experiment package contains extragalactic experiment, galactic monitor experiment, Scorpio monitor experiment, and galactic absorption experiment. Spin stabilized. Weight: 196.7 kg.	516 509 94.9 3.0	Third in a series of NASA Small Astronomy Satellites launched into equatorial orbit from San Marco range by an Italian crew. Improved spacecraft has extended spectral range and allows much longer, continuous observation of x-ray sources. During Aug. 1975, spacecraft established the position of the most powerful x-ray source ever detected and enabled ground observatories to optically identify it as transient nova in the constellation Orion
May 7 Anik 3 38A Thorad-Delta	Objective: To provide transmission of television, voice, and other data throughout Canada. Spacecraft: Cylindrical 1.8-m diameter and 3.4-m high. 1.5-m optically transparent antenna weighing 4.1-kg affixed to top of spacecraft remains stationary, pointed toward Canada as satellite revolves; spin stabilized. Provides 10 color TV channels or up to 9600 telephone circuits; 23,000 solar cells. Weight at launch: 544 kg. Weight in orbit: 272 kg.	35,789 35,786 1436.2 0.0	Launched by NASA for the Canadian Domestic Communications Satellite System into transfer orbit. Apogee kick motor fired by Canada May 10 and spacecraft placed in stationary orbit at 119° west longitude. Last of a series of three communications satellites launched by NASA under a 1971 NASA-Canada agreement.
May 20 DSCS 2-5, 2-6 40A Titan IIIC	Objective: Communications (two payloads). Spacecraft: Not announced.	249 150 88.3 28.6	Failed to separate and attain final orbit. Decayed May 26, 1975.

Successful U.S. Launches—1975

Launch date (G.m.t.) Spacecraft name Cospar designation Launch vehicle	Spacecraft data	Apogee and perigee (kilometers) Period (minutes) Inclination to equator (degrees)	Remarks
May 22 Intelsat IV F-1 42A Atlas-Centaur	Objective: To provide equivalent of 3000 to 9000 telephone circuits simultaneously or 12 color TV channels or a combination of telephone, TV, and other forms of communications traffic. Spacecraft: Cylindrical 2.38-m diameter and 5.28-m high; spin stabilized; 12 communications repeaters (transponders); 6 antennas (2 global transmit antennas, 2 global receive antennas, and 2 steerable spot-beam antennas); 45,012 solar cells. Weight at liftoff: 1387 kg. Weight after apogee motor fire: 700 kg.	36,184 35,704 1444.2 0.5	Launched by NASA for Comsat Corp., manager of Intelsat. Seventh and last successfully orbited satellite in Intelsat IV series. Apogee motor fired by Comsat on May 24 and satellite stationed at 62.5° east longitude over Indian Ocean. Commercial operations began June 1975.
May 24 Defense 43A Thor-Burner IIA	Objective: Development of space flight techniques and technology. Spacecraft: Not announced.	889 814 101.9 98.9	Still in orbit.
June 8 Defense 51A Titan IIID	Objective: Development of space flight techniques and technology. Spacecraft: Not announced.	272 157 88.7 96.3	Decayed November 5, 1975.
June 8 SSU-1 51C Titan IIID	Objective: Development of space flight techniques and technology. Spacecraft: Not announced.	1401 1385 113.6 95.1	Still in orbit.
June 12 Nimbus 6 52A Thorad-Delta	Objective: To make important early contributions to the Global Atmospheric Research Program by refining and extending the capability for vertically sounding the temperature and moisture structure of the atmosphere, particularly with regard to altitude resolution and with regard to the interfering effects of clouds by acquisition of synoptic data for a period of three months from either the High Resolution Infrared Sounder (HIRS) or the Scanning Microwave Spectrometer (SCAMS) or by determining the tropical circulation by obtaining three months of data from the Tropical Winds, Energy Conversion, and Reference Level Experiment (TWERLE). To provide experimental monitoring of environmental conditions such as sea ice cover and rainfall through three months of data obtained from the operation of the Electrically Scanning Microwave Radiometer (ESMR) or through the monitoring of the planetary radiation budget through data from the Earth Radiation Budget (ERB) experiment for a period of three months and through the demonstration and extension of the capability for vertically sounding the temperature structure or the water vapor and ozone concentrations of the atmosphere by the acquisition of three months of data from the Limb Radiance Inversion Radiometer (LRIR) or the Pressure Modulated Radiometer (PMR). Spacecraft: Butterfly-shaped spacecraft 3-m high and 3.3-m wide with solar panels extended, consists of three major elements: a 1.5-m diameter torus ring forms the base and houses the major spacecraft electronics; a smaller hexagon-shaped housing, connected to the ring by a truss, houses the attitude stabilization and control system; and two solar panels about 1-m by 2.5-m. Active 3-axis stabilization; carries nine experiments. Solar cells provide 550 watts of power and eight nickel-cadmium batteries average 270 watts. Weight: 827 kg.	1104 1097 107.2 99.9	Most sophisticated meteorological satellite yet developed. Sixth in Nimbus series, satellite was launched into circular, near-polar orbit. All nine experiments provided useful information. Transmitted sensor, telemetry, and ranging signals to ATS-6. Data collected will assist development of numerical models of the atmosphere for the international Global Atmospheric Research Program (GARP).

Successful U.S. Launches—1975

Launch date (G.m.t.) Spacecraft name Cospar designation Launch vehicle	Spacecraft data	Apogee and perigee (kilometers) Period (minutes) Inclination to equator (degrees)	Remarks
June 18 Defense 55A Atlas-Agena	Objective: Development of space flight techniques and technology. Spacecraft: Not announced.	40,800 30,200 1422 9	Still in orbit.
June 21 OSO-8 57A Thorad-Delta	Objective: To investigate the Sun's lower corona, the chromosphere, and their interface in the ultraviolet spectral region to better understand the transport of energy from the photosphere into the corona. Spacecraft: Consists of two sections: a rotating polyhedron, called the wheel, carries non-pointing experiments; a rectangular section mounted on top of the wheel, called the sail, consists of solar array and carries pointing experiments. 324.6-cm high spacecraft is spin stabilized and wheel diameter is 152.4-cm. Carries eight experiments including cosmic x-ray telescopes and spectrometers; two nickel-cadmium batteries; data handling and telemetry system. Weight: 1,088 kg.	560 543 95.7 32.9	Eighth in Orbiting Solar Observatory series, spacecraft is larger and more sophisticated than previous OSO spacecraft. Placed successfully into circular orbit, spacecraft is conducting studies of present minimum phase of solar cycle to compare with the intense solar activity expected during the 1980-82 peak. All eight experiments turned on; pointed experiments have conducted large scans of entire Sun.
July 15 Apollo (ASTP) 66A Saturn IB	Objective: To perform spacecraft rendezvous; to perform spacecraft docking and undocking; to conduct intervehicular crew transfer; to demonstrate the interaction of U.S. and U.S.S.R. control centers; to demonstrate the interaction of U.S. and U.S.S.R. spacecraft crews. Spacecraft: Apollo Block II command and service modules (CSM) modified for increased habitability needs of ASTP mission. Command module is conical, 3.9-m in diameter and 3.49-m high, and has a habitable volume of 5.94-m^3. Service module is cylindrical, 3.9-m in diameter and 7.57-m long, with a 88.965-newton thrust main propulsion engine, redundant reaction control systems, fuel cells, oxygen, and radiators. Docking module (DM) is basically a 3.15-m long and 1.4-m diameter airlock with docking facilities on each end. Combined weight of CSM/DM at orbital insertion: 14,856 kg.	230 219 89.0 51.8	Apollo crew consisted of Thomas P. Stafford, commander; Vance D. Brand, command module pilot; Donald K. Slayton, docking module pilot. First international manned space flight. Apollo docked with passive Soyuz at 12:19 p.m. e.d.t. July 17. Four crew transfers accomplished during near-two day joint flight. Crew activity during docked flight included joint engineering and scientific experiments, TV from each spacecraft, and a joint press conference. Apollo undocked at 8:02 a.m. e.d.t. July 19. Soyuz deorbited July 21 and Apollo continued in orbit with crew conducting experiments. Apollo landed in Pacific at 5:18 p.m. e.d.t. July 24, concluding final U.S. manned space flight until end-of-decade space shuttle missions.
Aug. 9 COS-B 72A Thorad-Delta	Objective: To study the extraterrestrial gamma radiation in the energy range from 25 MEV to 1 GEV from a highly elliptical orbit and near-polar inclination. Spacecraft: 121-cm high cylinder with a 140-cm diameter contains a central spark chamber mounted in a central tube and surrounded by equipment platforms, triggering telescopes, photomultipliers, upper and lower geiger counters, and an energy calorimeter. Four monopole antennas extend 51.2-cm below bottom of cylindrical body for a total spacecraft height of 172.2-cm. Outer surface of spacecraft is covered with 9480 solar cells. Nitrogen cold-gas attitude control system maintains constant spacecraft spin. Weight: 277.5 kg.	99,002 442 2203.9 90.3	Satellite built by ESA (European Space Agency) and launched into highly elliptical, near-polar orbit by NASA. Astronomical observatory pointed initially toward the Crab Nebula and later reoriented toward x-ray source GX5-1. All spacecraft systems and experiments operating satisfactorily.

Successful U.S. Launches—1975

Launch date (G.m.t.) Spacecraft name Cospar designation Launch vehicle	Spacecraft data	Apogee and perigee (kilometers) Period (minutes) Inclination to equator (degrees)	Remarks
Aug. 20 **Viking 1** **75A** Titan IIIE-Centaur	Objective: To significantly advance the knowledge of the planet Mars by means of observations from Martian orbit and direct measurements in the atmosphere and on the surface during the 1975 opportunity. Particular emphasis will be placed on obtaining biological, chemical, and environmental data relevant to the existence of life on the planet at this time, at some time in the past, or the possibility of life existing at a future date. Spacecraft: Consists of a Viking Orbiter and a Viking Lander Capsule attached together during cruise flight. Orbiter body is an octagonal ring with 16 modular compartments. Measures 9.8-m across from the tips of the extended solar panels and 3.3-m high. Attached to outside body are the scan platform which supports the scientific instruments, propulsion system, four solar panels, and radio antennas. Orbiter instruments include a pair of high resolution, slow scan TV cameras, an infrared atmosphere water detector, and a high resolution infrared thermal detector. Subsystems include a multistart engine, nitrogen attitude and control system, high gain S-band and X-band subsystem (Orbiter to earth), low gain S-band subsystem (Orbiter to earth), relay radio subsystem (Lander to Orbiter), four solar panels, and two nickel-cadmium batteries. Lander body is a hollow six-sided aluminum box 46-cm deep and 150-cm wide enclosed by a top and bottom cover plate. The six sides are 109.2-cm and 55.9-cm alternately. Three 130-cm landing legs are attached to the three shorter sides. Clearance between the Lander bottom and the surface is 22.9-cm. Each leg has a main strut assembly and an A-frame assembly, to which is attached a circular 30.5-cm footpad. Lander scientific instruments include two cameras, a biology instrument, a gas chromatograph mass spectrometer, an x-ray fluorescence spectrometer, a meteorology instrument, and a seismometer. Two-piece dome bioshield encloses Lander and protects against contamination; aeroshell consists of heatshield for Mars entry; parachute system assists during landing. Subsystems include three descent engines, S-band communications, landing radar, a guidance and control computer, and two SNAP 19-style 35-watt radioisotope thermoelectric generators (RTG). Also contains a 3.1-m retractable boom surface sampler with shovel-like head. Weight of Orbiter: 2339 kg; weight of Lander: 1184.1 kg. Weight of combined spacecraft: 3523.1 kg.	Trans-Mars Trajectory	Launched successfully on trans-Mars trajectory, spacecraft will take pictures of Mars and conduct a detailed scientific examination of the planet, including a search for life. After a year long, 815-million km journey, Lander will separate from Orbiter, enter Mars atmosphere, and land at Chryse (19.5° N) in the planet's equatorial region in early July 1976. From highly eccentric Mars synchronous orbit, Orbiter will relay data from Lander to earth. Follow-on Viking 2 mission will conduct similar mission. Orbiters to operate for 144 days in Mars orbit with 62 days of concurrent operation. Landers will operate serially for 128 days on Mars surface. By the end of 1975, Viking 1 was 39.1 million km from Mars.

APPENDIX A-3—Continued

Successful U.S. Launches—1975

Launch date (G.m.t.) Spacecraft name Cospar designation Launch vehicle	Spacecraft data	Apogee and perigee (kilometers) Period (minutes) Inclination to equator (degrees)	Remarks
Aug. 27 Symphonie 2 77A Thorad-Delta	Objective: To test and demonstrate communications equipment for TV, radio, telephone, telegraph, and data transmission; to provide voice channels, or 1200 telephone circuits equivalent of two color TV channels and eight between Europe, Africa, and South America. Spacecraft: Flat hexagonal cylinder 1.85-m in diameter and 0.5-m high. Three solar panel wings folded against satellite body are deployed in geosynchronous orbit and extend to a tip-to-tip diameter of 2.5-m in an arrangement 120° apart around the body periphery. Apogee motor engine and nozzle, super high frequency antenna feed and reflectors, reception horn, and solar sensors are mounted on spacecraft top; VHF antennas are on underside. Three axis stabilized by cold gas system; two nickel-cadmium batteries. Weight: 402 kg.	35,870 35,364 1427.4 0.0	Second of two experimental communications satellites developed by France and Germany. Launched successfully by NASA into transfer orbit. Apogee motor fired by Germany on Aug. 29 and placed spacecraft in synchronous equatorial orbit at 11.5° west longitude over the Atlantic off the west coast of Africa. All spacecraft systems functioning normally.
Sept. 9 Viking 2 83A Titan IIIE-Centaur	Objective: To significantly advance the knowledge of the planet Mars by means of observations from Martian orbit and direct measurements in the atmosphere and on the surface during the 1975 opportunity. Particular emphasis will be placed on obtaining biological, chemical, and environmental data relevant to the existence of life on the planet at this time, at some time in the past, or the possibility of life existing at a future date. Spacecraft: Consists of a Viking Orbiter and a Viking Lander Capsule attached together during cruise flight. Orbiter body is an octagonal ring with 16 modular compartments. Measures 9.8-m across from the tips of the extended solar panels and 3.3-m high. Attached to outside body are the scan platform which supports the scientific instruments, propulsion system, four solar panels, and radio antennas. Orbiter instruments include a pair of high resolution, slow scan TV cameras, an infrared atmosphere water detector, and a high resolution infrared thermal detector. Subsystems include a multistart engine, nitrogen attitude and control system, high gain S-band and X-band subsystem (Orbiter to earth), low gain S-band subsystem (Orbiter to earth), relay radio subsystem (Lander to Orbiter), four solar panels, and two nickel-cadmium batteries. Lander body is a hollow six-sided aluminum box 46-cm deep and 150-cm wide enclosed by a top and bottom cover plate. The six sides are 109.2-cm and 55.9-cm alternately. Three 130-cm landing legs are attached to the three shorter sides. Clearance between the Lander bottom and the surface is 22.9-cm. Each leg has a main strut assembly and an A-frame assembly, to which is attached a circular 30.5-cm footpad. Lander scientific instruments include two cameras, a biology instrument, a gas chromatograph mass spectrometer, an x-ray fluorescence spectrometer, a meteorology instrument, and a seismometer. Two-piece dome bioshield encloses Lander and protects against contamination; aeroshell consists of heatshield for Mars entry; parachute system assists during landing. Subsystems include three descent engines, S-	Trans-Mars Trajectory	Second of two spacecraft launched successfully on trans-Mars trajectory, spacecraft will take pictures of Mars and conduct a detailed scientific examination of the planet, including a search for life. After a year long, 815-million km journey, Lander will separate from Orbiter, enter Mars atmosphere, and land at Cydonia (44.3° N) at southernmost extension of the northern polar hood in early September 1976. From highly eccentric Mars synchronous orbit, Orbiter will relay data from Lander to earth. Viking 1 and 2 Orbiters to operate for 144 days in Mars orbit with 62 days concurrent operation. Landers will operate serially for 128 days on Mars surface. By the end of 1975, Viking 2 was 41.1 million km from Mars.

APPENDIX A-3—Continued

Successful U.S. Launches—1975

Launch date (G.m.t.) Spacecraft name Cospar designation Launch vehicle	Spacecraft data	Apogee and perigee (kilometers) Period (minutes) Inclination to equator (degrees)	Remarks
	band communications, landing radar, a guidance and control computer, and two SNAP 19-style 35-watt radioistotope thermoelectric generators (RTG). Also contains a 3.1-m retractable boom surface sampler with shovel-like head. Weight of Orbiter: 2339 kg; Weight of Lander: 1182.7 kg. Weight of combined spacecraft: 3521.7 kg.		
Sept. 26 Intelsat IVA F-1 91A Atlas-Centaur	Objective: To provide 6250 two-way voice circuits plus two television channels simultaneously or a combination of telephone TV, and other forms of communications traffic. Spacecraft: Overall height of 6.99-m and 2.38-m in diameter. Consists of two main elements: rotating cylinder covered with solar cells contains power subsystem, positioning and orientation subsystem, apogee motor, and despin control subsystem; despun earth-oriented platform atop rotating cylinder contains 20 communications repeaters (transponders), new antenna reflectors, and telemetry and command subsystems. Antenna reflectors are supported by a single tubular mast. 134.6-cm transmit and 88.9-cm receive quasi-square reflectors are constructed of a metallic mesh on an open web frame. Feed horn arrays and global horns are cantilevered from the base of the mast. Telemetry and command omni-directional bicone antenna is mounted on the mast tip. Weight at liftoff: 1515 kg. Weight after apogee motor fire: 825.5 kg.	35,821 35,294 1424.4 0.1	First of improved Intelsat IVA series has twice the communications capacity of Intelsat IV series. Launched by NASA for Comsat Corp., manager of Intelsat. Apogee motor fired Sept. 27 and satellite stationed at 21.5° west longitude over Atlantic Ocean. To begin commercial operations in 1976.
Oct. 6 Explorer 54 (AE) 96A Thorad-Delta	Objective: To investigate the chemical processes and energy transfer mechanisms which control the structure and behavior of the earth's atmosphere and ionosphere through the region of high solar energy absorption. Spacecraft: 16-sided cylindrical polyhedron with 135-cm diameter and 115-cm high. Spacecraft surface, except for one end and instrument openings, is covered by solar cells. Scientific instruments are mounted on two baseplates attached to a center column which is the main structural support. Column extends through the two baseplates to support a 122-cm diameter momentum wheel, the principal component of the attitude control system. Omni-directional S-band antenna is mounted in the spacecraft equatorial plane. Hydrazine propulsion system has three thrusters. Three nickel-cadmium batteries. 12 scientific instruments. Weight: 675 kg.	3816 154 126.9 90.1	Second of a series of three second-generation spacecraft designed to extend knowledge of the atmosphere. Launched into elliptical polar orbit, spacecraft dips in and out of earth's atmosphere. All 12 science instruments functioning normally.
Oct. 9 Defense 98A Titan IIIB-Agena	Objective: Development of space flight techniques and technology. Spacecraft: Not announced.	357 119 89.3 96.4	Still in orbit.
Oct. 12 Transit Improvement Program (TIP) 2 99A Scout	Objective: To test a developmental satellite providing improved operational characteristics for the Transit navigation system; to be integrated into the operational Transit system. Spacecraft: Solar panels and accordian-like boom deploy after insertion into proper orbit; hydrazine fuel motor. Weight: 165 kg.	699 357 95.2 90.7	Second of a series in U.S. Navy Transit Improvement Program. Launched into proper elliptical polar transfer orbit by NASA for U.S. Navy. Solar panels failed to deploy. Navy attempting to salvage mission.

Successful U.S. Launches—1975

Launch date (G.m.t.) Spacecraft name Cospar designation Launch vehicle	Spacecraft data	Apogee and perigee (kilometers) Period (minutes) Inclination to equator (degrees)	Remarks
Oct. 16 Goes 1 100A Thorad-Delta	Objective: To launch the spacecraft into a synchronous orbit of sufficient accuracy to enable it to accomplish its operational mission requirements, conduct an in-orbit evaluation and checkout of the spacecraft, and, upon completion of this evaluation, turn operational control over to NOAA/NESS, to provide regular and useful daytime and nighttime meteorological observations in support of the national operational meteorological satellite system. Spacecraft: Cylindrical 190.5-cm in diameter and 344-cm long from the top of the magnetometer to the bottom of the apogee boost motor. TE-364-4 apogee motor measures 90-cm high and is ejected after synchronous orbit is attained. Thrust tube located in center supports radiometer/telescope instrument. Scanning mirror looks out through an opening in cylindrical solar array whose panels cover outer walls of spacecraft. Instrumentation consists of a visible infrared spin scan radiometer (VISSR) to provide high quality day/night cloud cover data and to measure radiance temperatures of the earth/atmosphere system, a meteorological data collection and transmission system, and a space environmental monitor (SEM) system to measure proton, electron, and solar x-ray fluxes and magnetic fields. Spin stabilized. Weight at launch: 628 kg. Weight in orbit: 272 kg.	36,082 35,775 1443.4 1.0	First operational spacecraft of a series of Geostationary Operational Environmental Satellites, launched by NASA for NOAA. After successful launch into transfer orbit, apogee boost motor was fired Oct. 17 and spacecraft was placed in synchronous orbit at 55° west longitude. Spacecraft turned over to NOAA Oct. 30 and was placed at 75° west longitude (over northern Brazil). Beginning Jan. 1976, will form operational system with SMS-2 to provide 24-hr coverage of Western Hemisphere, providing cloud cover pictures to NOAA every 30 minutes.
Nov. 20 Explorer 55 (AE) 107A Thorad-Delta	Objective: To investigate the chemical processes and energy transfer mechanisms which control the structure and behavior of the earth's atmosphere and ionosphere through the region of high solar energy absorption. Spacecraft: 16-sided polyhedron measures 1[illegible]5-cm high and 135-cm in diameter. Nearly entire spacecraft surface is covered by a solar array of 2 x 2-cm N on P solar cells. Two baseplates are attached to center column and support scientific instruments; column also supports 122-cm diameter momentum wheel, the principal component of the attitude control system. Two redundant thrusters, fueled by 168 kg of hydrazine contained in six separate tanks, are mounted radially and provide the propulsion for altitude changes; a third yaw thruster changes spacecraft attitude. Spacecraft operates in either spinning or despun mode; omnidirectional S-band antenna is mounted on spacecraft equatorial plane. Three nickel-cadmium batteries. 12 scientific instruments include Backscatter Ultraviolet Instrument (BUV) to measure atmospheric distribution of ozone in equatorial region. Weight: 720 kg.	3025 157 118 19.7	Last of a series of three second-generation spacecraft designed to extend knowledge of the atmosphere. Launched into elliptical equatorial orbit, spacecraft dips in and out of earth's atmosphere. All 12 scientific instruments performing satisfactorily. Will measure spatial distribution of ozone.
Dec. 4 Defense 114A Titan IIID	Objective: Development of space flight techniques and technology. Spacecraft: Not announced.	241 157 88.5 96.3	Still in orbit.
Dec. 4 Defense 114B Titan IIID	Objective: Development of space flight techniques and technology. Spacecraft: Not announced.	1555 234 102.9 96.3	Still in orbit.

Successful U.S. Launches—1975

Launch date (G.m.t.) Spacecraft name Cospar designation Launch vehicle	Spacecraft data	Apogee and perigee (kilometers) Period (minutes) Inclination to equator (degrees)	Remarks
Dec. 13 RCA-Satcom-1 117A Thorad-Delta	Objective: To provide contiguous United States, Hawaii, and Alaska with television, voice channels, and high-speed data transmissions; to operate all 24 transponder channels at specified power throughout the minimum 8-year satellite lifetime, including eclipse periods. Spacecraft: Box-shaped 1.2-m x 1.2-m x 1.6-m high with two rectangular solar panels extending out from spacecraft on short booms. Hydrazine propellant tanks protrude from both east and west panels of spacecraft body; the two remaining main body panels support communications transponders and housekeeping equipment. Each bifoid solar array is 1.6-m x 2.3-m and provide a total of [illegible]96 sq m of silicon solar cells. The 24-channel communications subsystem consists of a fixed, paraboloidal, four-reflector antenna assembly and a lightweight transponder of high efficiency; traveling-wave-tube-amplifiers (TWTA); and low-density microwave filters. Six feedhorns are used to provide both vertically and horizontally polarized beams to Alaska, Hawaii, and the contiguous United States. During transfer orbit phase, spacecraft is spin stabilized; during operational phase, it is three-axis stabilized. Solid propellant apogee kick motor places spacecraft in geosynchronous orbit and hydrazine monopropellant reaction control system maintains correct position. Three nickel-cadmium batteries. Weight at launch: 868 kg. Weight after apogee motor fire: 463 kg.	36,085 35,625 1439.7 0.3	Launched into transfer orbit by NASA for RCA Corp. Apogee kick motor fired by RCA Dec. 15 and spacecraft placed in stationary orbit at 119° west longitude over equator (due south of Los Angeles). First of a series of three RCA domestic comsats. Commercial operations to begin March 1976.
Dec. 14 Defense 118A Titan IIIC	Objective: Development of space flight techniques and technology. Spacecraft: Not announced.	35,785 35,671 1436 3.0	Still in orbit.

APPENDIX B-1

U.S. Applications Satellites 1971-1975

Date	Name	Launch Vehicle	Remarks
		COMMUNICATIONS	
Jan. 26, 1971	Intelsat IV (F-2)	Atlas Centaur	First in Intelsat IV series of spacecraft; 3-9,000, 2-way voice circuits or 12-color TV channels. Positioned over the Atlantic
Feb. 3, 1971	NATOSAT-II (NATO-B)	Thor-Delta (TAT)	Second NATO satellite, stationed over the Atlantic to carry military traffic.
Nov. 3, 1971	DSCS 2-1,2	Titan IIIC	Operational defense communications satellites launched as a pair to 24-hour synchronous orbits to provide high capacity voice, digital, and secure voice communications for military networks.
Dec. 19, 1971	Intelsat IV (F-3)	Atlas Centaur	Second in new hign-capacity series. Positioned over Atlantic.
Jan. 22, 1972	Intelsat IV (F-4)	Atlas Centaur	Third in new high capacity series. Positioned over Pacific.
June 13, 1972	Intelsat IV (F-5)	Atlas Centaur	Fourth in new high capacity series. Positioned over Indian Ocean.
Oct. 15, 1972	Oscar VI	Thor-Delta (TAT)	Amateur radio relay.
Nov. 9, 1972	Anik 1 (Telesat 1)	Thor-Delta (TAT)	Launched for Canada.
Apr. 20, 1973	Anik 2 (Telesat 2)	Thor-Delta (TAT)	Launched for Canada.
Aug. 24, 1973	Intelsat IV (F-7)	Atlas Centaur	Fifth in high-capacity series. Positioned over Atlantic.
Dec. 13, 1973	DSCS 2-3,4	Titan IIIC	Follow-on to DSCS 2-1,2.
Jan. 19, 1974	Skynet 2A	Thor-Delta (TAT)	Launched for the United Kingdom in response to an agreement to augment the DSCS program. Spacecraft failed to achieve the proper orbit.
Apr. 13, 1974	Westar 1	Thor-Delta (TAT)	Launched for the Western Union Co. to establish a domestic communications link.
May 30, 1974	ATS-6	Titan IIIC	Multipurpose experimental satellite especially designed for regional services in North America and later India.
Oct. 10, 1974	Westar 2	Thor-Delta (TAT)	Launched for the Western Union Co. as part of their domestic communications links.
Nov. 21, 1974	Intelsat IV (F-8)	Atlas Centaur	Sixth in high-capacity series. Positioned over Pacific.
Nov. 23, 1974	Skynet 2B	Thor-Delta (TAT)	Launched for the United Kingdom in response to an agreement to augment the DSCS program. Spacecraft positioned over Indian Ocean.
Dec. 19, 1974	Symphonie 1	Thor-Delta (TAT)	First of two experimental satellites for France and West Germany. Spacecraft positioned over Atlantic.
May 7, 1975	Anik 3 (Telesat 3)	Thor-Delta (TAT)	Launched for Canada.
May 22, 1975	Intelsat IV (F-1)	Atlas Centaur	Eighth in high-capacity series. Positioned over Indian Ocean.
Aug. 27, 1975	Symphonie 2	Thor-Delta (TAT)	Launched for France and West Germany. Positioned over the Atlantic.
Sep. 26, 1975	Intelsat IV A (F-1)	Atlas Centaur	First of a new series double the capacity of its predecessors. Positioned over the Atlantic.
Dec. 13, 1975	RCA-Satcom-1	Thor-Delta (TAT)	Launched for RCA as first of their communication satellite series. Positioned over the Pacific.

Appendix B-1 Continued

U.S. Applications Satellites 1971-1975

Date	Name	Launch Vehicle	Remarks
WEATHER OBSERVATION*			
Aug. 16, 1971	Eole (CAS-1)	Scout	French satellite to gather data from constant density surface balloons relaying meteorological data for the study of the characteristics and movements of air masses. New balloons are released daily from 3 sites in Argentina, for this cooperative French United States project.
Oct. 15, 1972	NOAA-2 (ITOS D)	Thor-Delta	Second generation operational meteorological satellite.
Dec. 11, 1972	Nimbus V	Thor-Delta	Provided the first atmospheric vertical temperature profile measurements through clouds.
Nov. 6, 1973	NOAA-3 (ITOS F)	Thor-Delta	Second generation operational meteorological satellite.
May 17, 1974	SMS 1	Thor-Delta	First full-time weather satellite in synchronous orbit.
Nov. 15, 1974	NOAA-4 (ITOS G)	Thor-Delta	Second generation operational meteorological satellite.
Feb. 6, 1975	SMS-2	Thor-Delta	Second full-time weather satellite in synchronous orbit.
June 12, 1975	Nimbus 6	Thor-Delta	To build numerical models for Global Atmospheric Research Program.
Oct. 16, 1975	Goes 1	Thor-Delta	First fully operational synchronous weather satellite.
EARTH OBSERVATION			
July 23, 1972	ERTS-1	Thor-Delta	Acquired synoptic multi-spectral repetitive images that are proving useful in such disciplines as agriculture and forestry resources, mineral and land resources, land use, water resources, marine resources, mapping and charting, and the environment.
Jan. 22, 1975	Landsat 2	Thor-Delta	Second experimental Earth resources technology satellite.
GEODESY			
Apr. 9, 1975	Geos 3	Thor-Delta	To measure geometry and topography of ocean surface.
NAVIGATION			
Sept. 2, 1972	Triad OI-1	Scout	First experimental station keeping Transit navigation satellite.
Oct. 30, 1973	NavSat O-20	Scout	
Jul. 14, 1974	NTS 1	Atlas F	Navigation technology satellite.
Oct. 12, 1975	Tip-2	Scout	Transit Improvement Program.

* Does not include Department of Defense weather satellites which are not individually identified by launch.

APPENDIX B-2

U.S.-Launched Scientific Payloads 1971-1975

Date	Name	Launch Vehicle	Remarks
Mar. 13, 1971	IMP 8 (Explorer 43)	Thor Delta	Study of solar-lunar-terrestrial relationships in the radiation environment of the interplanetary magnetic field.
Apr. 1, 1971	ISIS 2	Thor Delta	Electron production and loss, and large scale transport of ionization. (Canadian payload.)
June 8, 1971	SESP 1	Thor Burner II	Defense scientific experiments.
June 8, 1971	Solrad 10 (Explorer 44)	Scout	Monitor sun's x-ray and UV emissions.
Aug. 7, 1971	OV 1-20	Atlas Satar	Defense scientific experiment.
Aug. 7, 1971	OV 1-21	Atlas Satar	Defense scientific experiment.
Aug. 7, 1971	AVL802	Atlas Satar	Defense scientific experiment.
Sep. 29, 1971	OSO 7	Thor Delta	Observe active physical processes on the sun.
Oct. 17, 1971	STP (SESP 71-2)	Thor Agena	Defense scientific experiments.
Nov. 15, 1971	SSS (Explorer 45)	Scout	Investigate ring current and magnetic storms, acceleration of charged particles (Italian launched.)
Dec. 11, 1971	Ariel 4	Scout	Investigate interactions among the plasma, charged particle streams, electromagnetic waves (United Kingdom payload.)
Jan. 31, 1972	HEOS A-2	Thor Delta	Investigate interplanetary space and high latitude magnetosphere. (International cooperative payload.)
Mar. 12, 1972	TD-1	Thor Delta	Seven ESRO experiments.
Aug. 13, 1972	MTS (Explorer 46)	Scout	Meteoroid penetration rate study.
Aug. 21, 1972	OAO 3	Atlas Centaur	Precise astronomical observation from above the atmosphere.
Sep. 23, 1972	IMP 9 (Explorer 47)	Thor Delta	Study cislunar space radiation environment, plus magnetic data.
Oct. 2, 1972	Radcat	Atlas Burner II	Defense scientific experiment.
Oct. 2, 1972	Radsat	Atlas Burner II	Defense scientific experiment.
Nov. 15, 1972	SAS B (Explorer 48)	Scout	Survey of high energy gamma radiation including point sources. (Italian launched.)
Nov. 22, 1972	ESRO 4	Scout	Polar ionosphere studies (ESRO payload.)
Dec. 16, 1972	Aeros I	Scout	Study of upper atmosphere and ionospheric F region. (German payload.)
June 10, 1973	Radio Astronomy 2 (Explorer 49)	Thor Delta	Measure galactic and solar radio noise shielded from earth by the moon, by use of lunar orbit.
Oct. 26, 1973	IMP 10 (Explorer 50)	Thor Delta	Study of interplanetary environment particle and fuel interactions in the distant magneto tail.
Dec. 16, 1973	Atmosphere (Explorer 51)	Thor Delta	Photochemical processes in absorption of solar UV.
Feb. 18, 1974	San Marco 4	Scout	Diurnal variations in equatorial neutral atmosphere. (Italian payload and launch.)
Mar. 9, 1974	UK X-4 (Miranda)	Scout	Measure density of sun reflecting particles near the spacecraft, and test engineering systems. (United Kingdom payload.)
June 3, 1974	Hawkeye (Explorer 52)	Scout	Plasma properties of the magnetosphere over the north polar cap.
July 16, 1974	Aeros 2	Scout	Measure aeronomic parameters of upper atmosphere and solar UV. (German payload.)
Aug. 30, 1974	ANS	Scout	Study steller UV and x-ray sources. (Netherlands payload.)
Oct. 15, 1974	Ariel 5	Scout	Study galactic and extragalactic x-ray sources. (United Kingdom payload.)
Nov. 15, 1974	INTASAT	Thor Delta	Measure ionospheric total electron content, ionospheric irregularities and scintillation. Spanish payload.
May 7, 1975	SAS-C (Explorer 53)	Scout	Measure X-ray emission of discrete extragalactic sources. (Italian-launched.)
June 21, 1975	OSO-8	Thor-Delta	To study minimum phase of solar cycle.
Aug. 9, 1975	COS-B	Thor-Delta	Extraterrestrial gamma radiation studies. (ESA European satellite.)
Oct. 6, 1975	Atmosphere (Explorer 54)	Thor-Delta	Photochemical processes in absorption of solar energy.
Nov. 20, 1975	Atmosphere (Explorer 55)	Thor-Delta	Photochemical processes in absorption of solar energy. Measure spatial distribution of ozone.

Appendix B-3

U.S.-Launched Space Probes 1971-1975

Date	Name	Launch Vehicle	Remarks
May 8, 1971	Mariner 8	Atlas Centaur	Mars orbital photographic mission. Launch failure.
May 30, 1971	Mariner 9	Atlas Centaur	Mars orbital photographic mission. Entered orbit of Mars Nov. 13, 1971. Returned 6,876 pictures and data on temperatures, elevations, and water vapor.
Mar. 3, 1972	Pioneer 10	Atlas Centaur	Jupiter flyby mission. Passed Jupiter on Dec. 3, 1973, returned color pictures and data on radiation, temperatures, and magnetic fields. Accelerated toward solar system escape.
Apr. 6, 1973	Pioneer 11	Atlas Centaur	Jupiter flyby mission. Passed Jupiter on Dec. 2, 1974, returning pictures and data and headed for a similar pass by Saturn before accelerating out of the solar system.
Nov. 3, 1973	Mariner 10	Atlas Centaur	Venus and Mercury flyby mission. Passed Venus on Feb. 5, 1974, returning good quality pictures. Passed Mercury again on Sep. 21, 1974, returning 500-600 good quality pictures. Will pass Mercury again on Mar. 16, 19715. Other data were also returned.
Dec. 10, 1974	Helios 1	Titan IIIE-Centaur	Investigate properties of interstellar space close to Sun. W. German payload.
Aug. 20, 1975	Viking 1	Titan IIIE-Centaur	Mars lander and orbiter mission to arrive in mid-1976.
Sep. 9, 1975	Viking 2	Titan IIIE-Centaur	Mars lander and orbiter mission to arrive in mid-1976.

APPENDIX C

History of U.S. and Soviet Manned Space Flights

Spacecraft	Launch Date	Crew	Flight time	Highlights
Vostok 1	Apr. 12, 1961	Yuri A. Gagarin	1 h 48 min.	First manned flight.
Mercury-Redstone 3	May 5, 1961	Alan B. Shepard, Jr.	15 min.	First U.S. flight; suborbital.
Mercury-Redstone 4	July 21, 1961	Virgil I. Grissom	16 min.	Suborbital; capsule sank after landing.
Vostok 2	Aug. 6, 1961	Gherman S. Titov	25 h 18 min.	First flight exceeding 24 h.
Mercury-Atlas 6	Feb. 20, 1962	John H. Glenn, Jr.	4 h 55 min.	First American to orbit.
Mercury-Atlas 7	May 24, 1962	M. Scott Carpenter	4 h 56 min.	Landed 250 mi from target.
Vostok 3	Aug. 11, 1962	Andrian G. Nikolayev	94 h 22 min.	First dual mission (with Vostok 4).
Vostok 4	Aug. 12, 1962	Pavel R. Popovich	70 h 57 min.	Came within 4 mi of Vostok 3.
Mercury-Atlas 8	Oct. 3, 1962	Walter M. Schirra, Jr.	9 h 13 min.	Landed 5 mi from target.
Mercury-Atlas 9	May 15, 1963	L. Gordon Cooper, Jr.	34 h 20 min.	First long U.S. flight.
Vostok 5	June 14, 1963	Valery F. Bykovsky	119 h [illegible] min.	Second dual mission (with Vostok 6).
Vostok 6	June 16, 1963	Valentina V. Tereshkova	70 h 50 min.	First woman in space; within 3 mi of Vostok 5.
Voskhod 1	Oct. 12, 1964	Vladimir M. Komarov Konstantin P. Feoktistov Dr. Boris G. Yegorov	24 h 17 min.	First 3-man crew.
Voskhod 2	Mar. 18, 1965	Aleksei A. Leonov Pavel I. Belyayev	26 h 2 min.	First extravehicular activity (Leonov, 10 min).
Gemini 3	Mar. 23, 1965	Virgil I. Grissom John W. Young	4 h 53 min.	First U.S. 2-man flight; first manual maneuvers in orbit.
Gemini 4	June 3, 1965	James A. McDivitt Edward H. White, 2d	97 h 56 min.	21-min. extravehicular activity (White).
Gemini 5	Aug. 21, 1965	L. Gordon Cooper, Jr. Charles Conrad, Jr.	190 h 55 min.	Longest-duration manned flight to date.
Gemini 7	Dec. 4, 1965	Frank Borman James A. Lovell, Jr.	330 h 35 min.	Longest-duration manned flight to date.
Gemini 6-A	Dec. 15, 1965	Walter M. Schirra, Jr. Thomas P. Stafford	25 h 51 min.	Rendezvous within 1 ft of Gemini 7.
Gemini 8	Mar. 16, 1966	Neil A. Armstrong David R. Scott	10 h 41 min.	First docking of 2 orbiting spacecraft (Gemini 8 with Agena target rocket).
Gemini 9-A	June 3, 1966	Thomas P. Stafford Eugene A. Cernan	72 h 21 min.	Extravehicular activity; rendezvous.
Gemini 10	July 18, 1966	John W. Young Michael Collins	70 h 47 min.	First dual rendezvous (Gemini 10 with Agena 10, then Agena 8).
Gemini 11	Sept. 12, 1966	Charles Conrad, Jr. Richard F. Gordon, Jr.	71 h 17 min.	First initial rendezvous; first tethered flight; highest Earth-orbit altitude (853 mi).
Gemini 12	Nov. 11, 1966	James A. Lovell, Jr. Edwin E. Aldrin, Jr.	94 h 35 min.	Longest extravehicular activity to date (Aldrin, 5 h 37 min).
Soyuz 1	Apr. 23, 1967	Vladimir M. Komarov	26 h 37 min.	Cosmonaut killed in reentry accident.
Apollo 7	Oct. 11, 1968	Walter M. Schirra, Jr. Donn F. Eisele R. Walter Cunningham	260 h 9 min.	First U.S. 3-man mission.
Soyuz 3	Oct. 26, 1968	Georgi Beregovoy	94 h 51 min.	Maneuvered near unmanned Soyuz 2.
Apollo 8	Dec. 21, 1968	Frank Borman James A. Lovell, Jr. William A. Anders	147 h 1 min.	First manned orbit(s) of Moon; first manned departure from Earth's sphere of influence; highest speed ever attained in manned flight.
Soyuz 4	Jan. 14, 1969	Vladimir Shatalov	71 h 23 min.	Soyuz 4 and 5 docked and transferred 2 Cosmonauts from Soyuz 5 to Soyuz 4.
Soyuz 5	Jan. 15, 1969	Boris Volynov Aleksey Yeliseyev Yevgeniy Khrunov	72 h 56 min.	
Apollo 9	Mar. 3, 1969	James A. McDivitt David R. Scott Russell L. Schweickart	241 h 1 min.	Successfully simulated in Earth orbit operation of lunar module to landing and takeoff from lunar surface and rejoining with command module.
Apollo 10	May 18, 1969	Thomas P. Stafford John W. Young Eugene A. Cernan	192 h 3 min.	Successfully demonstrated complete system including lunar module descent to 47,000 ft from the lunar surface.
Apollo 11	July 16, 1969	Neil A. Armstrong Michael Collins Edwin E. Aldrin, Jr.	195 h 19 min.	First manned landing on lunar surface and safe return to Earth. First return of rock and soil samples to Earth, and manned deployment of experiments on lunar surface.

APPENDIX C Continued

History of U.S. and Soviet Manned Space Flights

Spacecraft	Launch Date	Crew	Flight time	Highlights
Soyuz 6	Oct. 11, 1969	Georgiy Shonin Valeriy Kubasov	118 h 42 min.	Soyuz 6, 7 and 8 operated as a group flight without actually docking. Each conducted certain experiments, including welding and Earth and celestial observations.
Soyuz 7	Oct. 12, 1969	Anatoliy Filipchenko Vladislav Volkov Viktor Gorbatko	118 h 41 min.	
Soyuz 8	Oct. 13, 1969	Vladimir Shatalov Aleksey Yeliseyev	118 h 50 min.	
Apollo 12	Nov. 14, 1969	Charles Conrad, Jr. Richard F. Gordon, Jr. Alan L. Bean	244 hr 36 min.	Second manned lunar landing. Continued manned exploration and retrieved parts of Surveyor III spacecraft which landed in Ocean of Storms on Apr. 19, 1967.
Apollo 13	Apr. 11, 1970	James A. Lovell, Jr. Fred W. Haise, Jr. John L. Swigert, Jr.	142 h. 55 min.	Mission aborted due to explosion in the service module. Ship circled Moon, with crew using LEM as "lifeboat" until just prior to reentry.
Soyuz 9	June 1, 1970	Andrian G. Nikolayev Vitaliy I. Sevastianov	424 h 59 min.	Longest manned space flight to date, lasting 17 days 16 h 59 min.
Apollo 14	Jan. 31, 1971	Alan B. Shepard, Jr. Stuart A. Roosa Edgar D. Mitchell	216 h 2 min.	Third manned lunar landing. Mission demonstrated pin-point landing capability and continued manned exploration.
Soyuz 10	Apr. 22, 1971	Vladimir Shatalov Aleksey Yeliseyev Nikolai Rukavishnikov	47 h 46 min.	Docked with Salyut 1, but crew did not board space station launched Apr. 19. Crew recovered Apr. 24, 1971.
Soyuz 11	June 6, 1971	Georgiy Timofeyevich Dobrovolskiy Vladislov Nikolayevich Volkov Viktor Ivanovich Patsayev	570 h 22 min.	Docked with Salyut 1 and Soyuz 11 crew occupied space station for 22 days. Crew perished during final phase of Soyuz 11 capsule recovery on June 30, 1971.
Apollo 15	July 26, 1971	David R. Scott Alfred M. Worden James Bensen Irwin	295 h 12 min.	Fourth manned lunar landing and first Apollo "J" series mission which carry the Lunar Roving Vehicle. Worden's in-flight EVA of 38 min 12 s was performed during return trip.
Apollo 16	Apr. 16, 1972	John W. Young Charls M. Duke, Jr. Thomas K. Mattingly, II	265 h 51 min.	Fifth manned lunar landing, with Lunar Roving Vehicle.
Apollo 17	Dec. 7, 1972	Eugene A. Cernan Harrison H. Schmitt Ronald E. Evans	301 hr 52 min.	Sixth and final Apollo manned lunar landing, with roving vehicle.
Skylab 2	May 25, 1973	Charles Conrad, Jr. Joseph P. Kerwin Paul J. Weitz	627 h 50 min.	Docked with Skylab 1 for 28 days. Repaired damaged station.
Skylab 3	July 28, 1973	Alan L. Bean Jack R. Lousma Owen K. Garriott	1,427 h 9 min.	Docked with Skylab 1 for over 59 days.
Soyuz 12	Sept. 27, 1973	Vasiliy Lazarev Oleg Makarov	47 h 16 min.	Checkout of improved Soyuz.
Skylab 4	Nov. 16, 1973	Gerald P. Carr Edward G. Gibson William R. Pogue	2,017 h 16 min.	Docked with Skylab 1 in continuing long duration mission.
Soyuz 13	Dec. 18, 1973	Petr Klimuk Valentin Lebedev	188 h 55 min.	Astrophysical, biological, and Earth resources experiments.
Soyuz 14	July 3, 1974	Pavel Popovich Yuriy Artyukhin	377 h 30 min.	Docked with Salyut 3 and Soyuz 14 crew occupied space station for over 14 days.
Soyuz 15	Aug. 26, 1974	Gennadiy Sarafanov Lev Demin	48 h 12 min.	Rendezvoused but did not dock with Salyut 3.
Soyuz 16	Dec. 2, 1974	Anatoliy Filipchenko Nikolai Rukavishnikov	142 h 24 min.	Test of ASTP configuration.
Soyuz 17	Jan. 10, 1975	Aleksey Gubarev Georgiy Grechko	709 h 20 min.	Docked with Salyut 4 and occupied station during a 29-day flight.
Anomaly	Apr. 5, 1975	Vasiley Lazarev Oleg Makarov	20 min.	Soyuz stages failed to separate; crew recovered after abort.
Soyuz 18	May 24, 1975	Petr Klimuk Vitaliy Sevastyanov	1511 h 20 min.	Docked with Salyut 4 and occupied station during a 63-day mission.
Soyuz 19	July 15, 1975	Aleksey Leonov Valeriy Kubasov	142 h 31 min.	Target for Apollo in docking and joint experiments ASTP mission.
Apollo	July 15, 1975	Thomas P. Stafford Donald K. Slayton Vance D. Brand	217 h 28 min.	Docked with Soyuz 19 in joint experiments of ASTP mission.

APPENDIX D

U.S. Space Launch Vehicles

Vehicle	Stages	Propellant[3]	Thrust (in thousands of lbs)	Max. dia. (ft)	Height (ft)	Max. Payload (lb) 300NM orbit	Max. Payload (lb) Escape	First launch
Scout	1. Algol IIIA	Solid	108.3	3.67	72.0	410[4]	85[4]	[1] 1972(60)
	2. Castor IIA	Solid	63.2					
	3. Antares IIB	Solid	28.5					
	4. Altair III	Solid	5.9					
Thor-Delta 2900 series	1. Thor plus	LOX/RP-1	205	8	116	3,900[4]	1,050[4]	1973(60)
	nine TX 354-5	Solid	99[2]					
	2. Delta (DSV-3)	N_2O_4/Aerozine	10.3					
	3. TE 364-4	Solid	15					
Atlas F/TE 364-4	1. Atlas booster and sustainer (Atlas F)	LOX/RP-1	443	10	85	3,300[4]		
	2. TE 364-4	Solid	15					
Atlas-Agena	1. Atlas booster and sustainer (SLV/3A)	LOX/RP-1	503	10	133	6,000[4]	1,000[4]	1968(60)
	2. Agena	IRFNA/UDMH	16					
Titan IIIB-Agena	1. LR-87	N_2O_4/Aerozine	520	10	159	7,100[5]	1,500[5]	1966
	2. LR-91	N_2O_4/Aerozine	100					
	3. Agena	IRFNA/UDMH	16					
Titan IIIC	1. Two 5-segment 120-in diameter	Solid	2,600	10x30	133	26,500[4]	7,000[4]	1965
	2. LR-87	N_2O_4/Aerozine	520					
	3. LR-91	N_2O_4/Aerozine	100					
	4. Transtage	N_2O_4/Aerozine	16					
Titan IIID	1. Two 5-segment 120-in diameter	Solid	2,600	10x30	154	6,500[5]		1971
	2. LR-87	N_2O_4/Aerozine	520					
	3. LR-91	N_2O_4/Aerozine	100					
Titan IIIE-Centaur	1. Two 5-segment 120-in diameter	Solid	2,600	10x30	160		11,300[4]	1974
	2. LR-87	N_2O_4/Aerozine	520					
	3. LR-91	N_2O_4/Aerozine	102					
	4. Centaur (Two RL-10)	LOX/LH	30					
Atlas-Centaur	1. Atlas booster and sustainer	LOX/RP	503	10	131	10,300[4]	2,500[4]	1967(62)
	2. Centaur (Two RL-10)	LOX/LH	30					
Saturn IB	1. S-IB (eight H-1)	LOX/RP	1,640	21.6	181	34,000[4]		1966
	2. S-IVB (one J-2)	LOX/LH	250					

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[1] The date of first launch applies to this latest modification with a date in parentheses for the initial version.

[2] Set of 3.

[3] Propellant abbreviations used are as follows: Liquid Oxygen and a modified Kerosene—LOX/RP; Solid propellant combining in a single mixture both fuel and oxidizer—Solid; Inhibited Red Fuming Nitric Acid and Unsymmetrical Dimethylhydrazine—IRFNA/UDMH; Nitrogen Tetroxide and UDMH/N_2H_4—N_2O_4/Aerozine; Liquid Oxygen and Liquid Hydrogen—LOX/LH.

[4] Due east launch.

[5] Polar launch.

APPENDIX E-1

Space Activities of the U.S. Government

19-YEAR BUDGET SUMMARY—BUDGET AUTHORITY
[In millions of dollars]

	NASA		Department of Defense	ERDA	Commerce	Interior	Agriculture	NSF	Total space
	Total	Space[1]							
1959	305.4	235.4	489.5	34.3					759.2
1960	523.6	461.5	560.9	43.3				.1	1,065.8
1961	964.0	926.0	813.9	67.7				.6	1,808.2
1962	1,824.9	1,796.8	1,298.2	147.8	50.[illegible]			1.3	3,294.8
1963	3,673.0	3,626.0	1,549.9	213.9	43.2			1.5	5,434.5
1964	5,099.7	5,046.3	1,599.3	210.0	2.8			3.0	6,861.4
1965	5,249.7	5,167.6	1,573.9	228.6	12.2			3.2	6,985.5
1966	5,174.9	5,094.5	1,688.8	186.8	26.5			3.2	6,999.8
1967	4,967.6	4,862.2	1,663.6	183.6	29.3			2.8	6,741.5
1968	4,588.8	4,452.5	1,921.8	145.1	28.1	0.2	0.5	3.2	6,551.4
1969	3,990.9	3,822.0	2,013.0	118.0	20.0	0.2	0.7	1.9	5,975.8
1970	3,745.8	3,547.0	1,678.4	102.8	8.0	1.1	0.8	2.4	5,340.5
1971	3,311.2	3,101.3	1,512.3	94.8	27.4	1.9	0.8	2.4	4,740.9
1972	3,306.6	3,071.0	1,407.0	55.2	31.3	5.8	1.6	2.8	4,574.7
1973	3,406.2	3,093.2	1,623.0	54.2	39.7	10.3	1.9	2.6	4,824.8
1974	3,036.9	2,758.5	1,766.0	41.7	60.2	9.0	3.1	1.8	4,640.3
1975	3,229.1	2,915.3	1,892.4	29.6	64.4	8.3	2.3	2.0	4,914.3
1976 Est.	3,552.8	3,229.6	1,985.1	34.1	70.9	10.4	3.9	2.4	5,336.4
T.Q.[2] Est.	931.7	852.4	448.3	8.4	21.9	2.6	1.0	0.6	1,335.2
1977 Est.	3,695.0	3,330.7	2,336.3	34.2	89.8	8.4	4.7	2.4	5,806.5

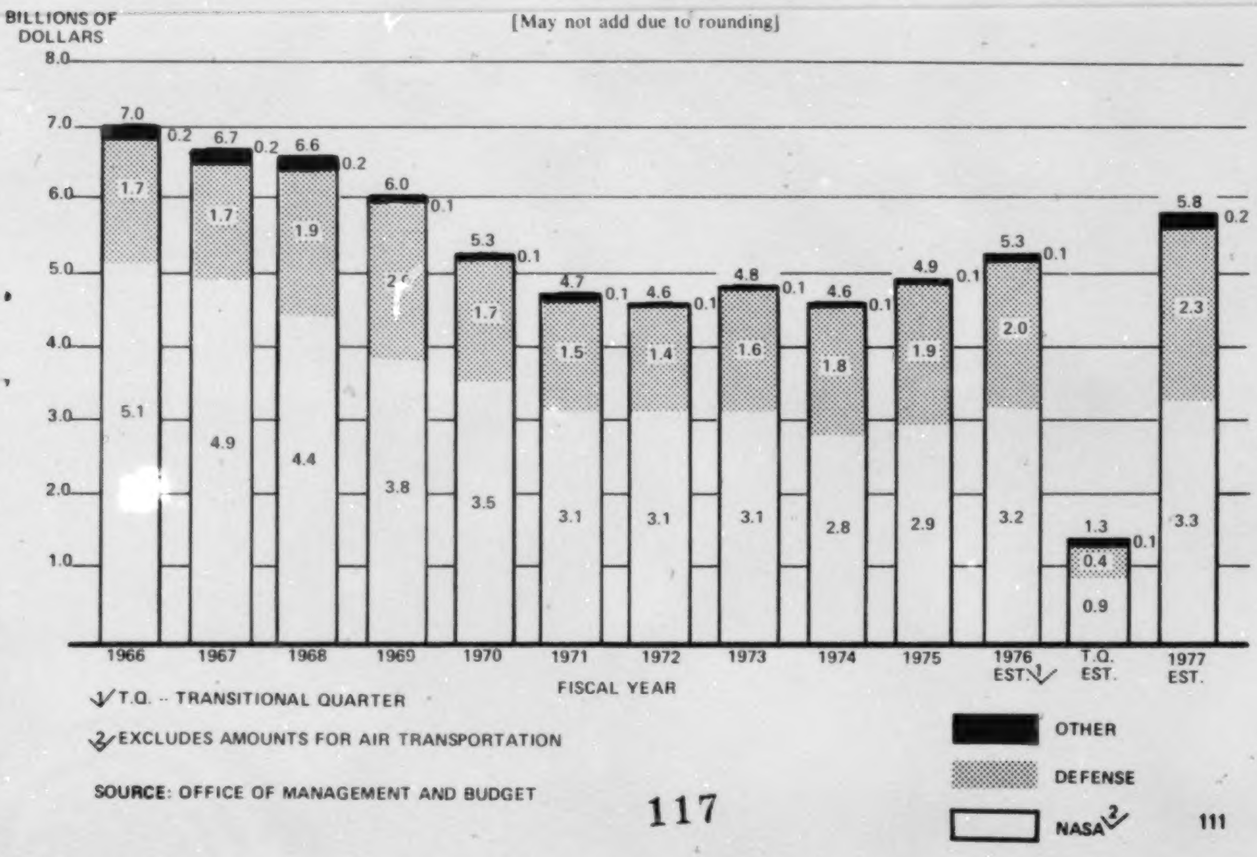
[1] Excludes amounts for air transportation.

[2] T.Q.—Transitional Quarter.

Source: Office of Management and Budget.

U.S. Space Budget—Budget Authority—1966-1977

[May not add due to rounding]



1 T.Q. – TRANSITIONAL QUARTER

2 EXCLUDES AMOUNTS FOR AIR TRANSPORTATION

SOURCE: OFFICE OF MANAGEMENT AND BUDGET

Appendix E–2

Space Activities Budget

(In millions of dollars)

	Budget Authority				Outlays			
	1975 Actual	1976 Est.	T.Q.[1] Est.	1977 Est.	1975 Actual	1976 Est.	T.Q.[1] Est.	1977 Est.
Federal space programs:								
NASA[2]	2915.3	3229.6	852.2	3330.7	2950.9	3187.4	828.3	3336.8
Defense	1892.4	1985.1	448.3	2336.3	1831.1	1962.0	525.6	2132.0
ERDA	29.6	34.1	8.4	34.2	34.3	34.3	9.6	32.3
Commerce	64.4	70.9	21.9	89.8	63.6	71.3	21.9	89.8
Interior	8.3	10.4	2.6	8.4	7.4	10.3	2.7	8.4
NSF	2.0	2.4	0.6	2.4	1.8	1.8	0.5	1.9
Agriculture	2.3	3.9	1.0	4.7	1.7	3.7	1.0	4.6
Total	4914.3	5336.4	1335.0	5806.5	4890.8	5271.7	1389.6	5605.8
NASA:								
Manned space flight	1510.3	1790.5	468.2	1891.0	1534.7	1734.7	468.5	1864.8
Space science, applications and technology	1077.1	1120.0	296.7	1086.9	1084.2	1117.6	280.5	1124.7
Air transportation	313.8	323.2	79.5	364.3	315.8	329.8	80.4	339.2
Supporting operations	329.8	321.4	87.8	354.8	334.0	337.3	79.6	349.3
Less receipts	—2.0	—2.2	—0.4	—2.0	—2.0	—2.2	—0.4	—2.0
Total NASA	3229.1	3552.8	931.7	3695.0	3266.7	3517.2	908.7	3676.0

[1] T.Q.—Transitional Quarter.

[2] Excludes amounts for air transportation.

Source: Office of Management and Budget.

Aeronautics Budget

(In millions of dollars)

	Budget Authority			
	1975 Actual	1976 Est.	T.Q.[1] Est.	1977 Est.
Federal aeronautics programs:				
NASA[2]	313.8	323.2	79.5	364.3
Department of Defense[3]	1627.0	1940.4	447.8	2273.4
Department of Transportation[4]	74.0	82.9	21.8	94.2
Total	2014.8	2346.5	549.1	2731.9

[1] T.Q.—Transitional Quarter.

[2] Research and Development, Construction of Facilities, Research and Program Management.

[3] Research, Development, Testing, and Equipment of aircraft and related equipment.

[4] Office of Secretary of Transportation and Federal Aviation Administration Research and Development.

Source: Office of Management and Budget.

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